Table of Contents—page 29

5 193

Heating · Piping and Air Conditioning

IN THIS ISSUE

Persistent Conservation Efforts Cut Steam for Heating in Half

Piping Calculations—How to Use Reynolds Numbers

Heat Balance Analysis for Air Conditioning

and many others

The Journal Section of the American Society of Heating and Ventilating Engineers

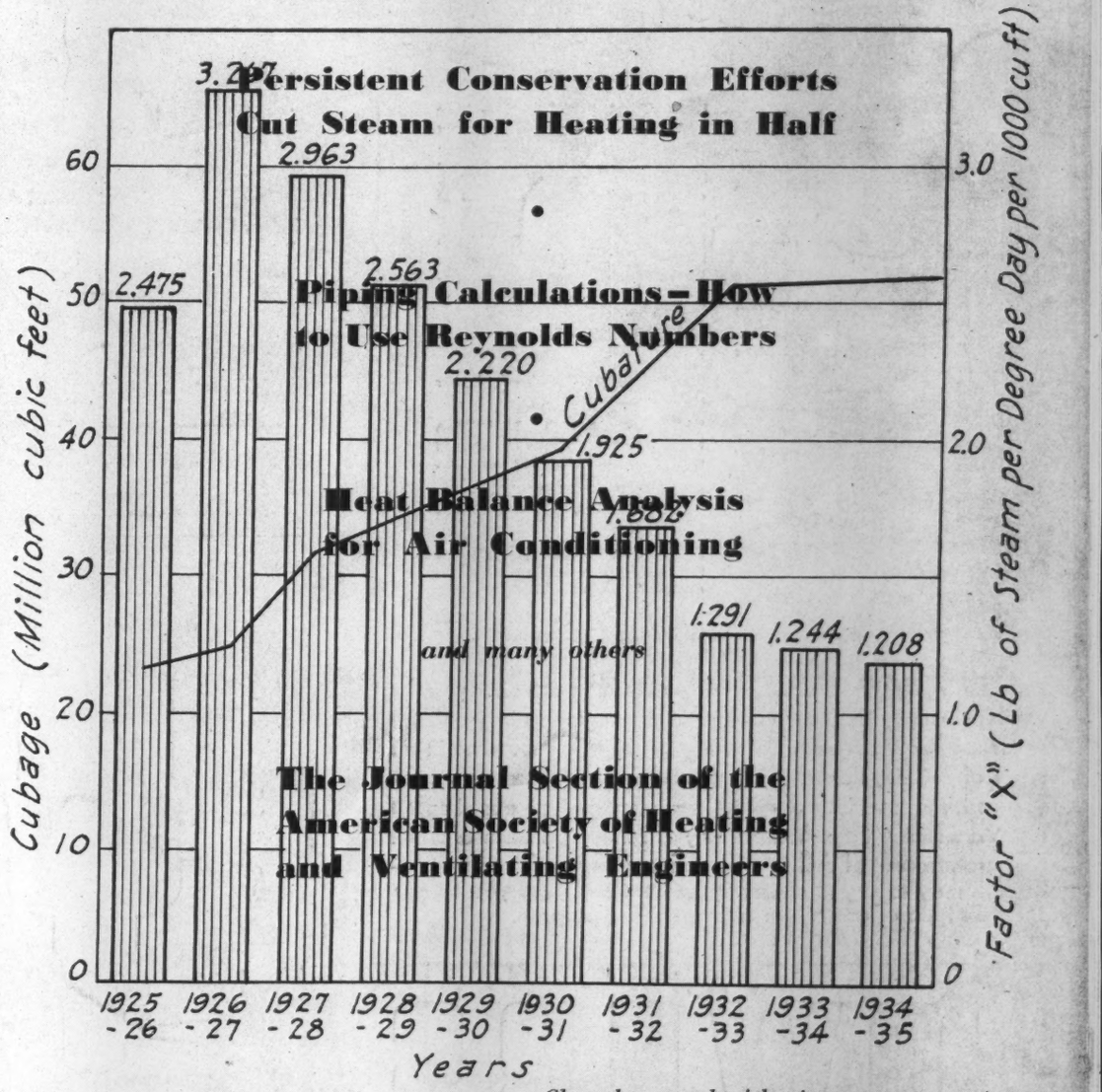
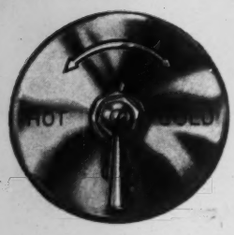
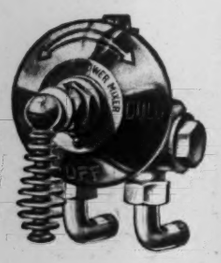


Chart shows result of heating steam conservation program explained this month

The most complete line of Controls made to regulate the temperature of Water!



Safety Shower Mixer for Individual Showers



Steam and Water Mixer

Only a few of the simple types of POWERS *controls for water temperatures are shown here*

for -

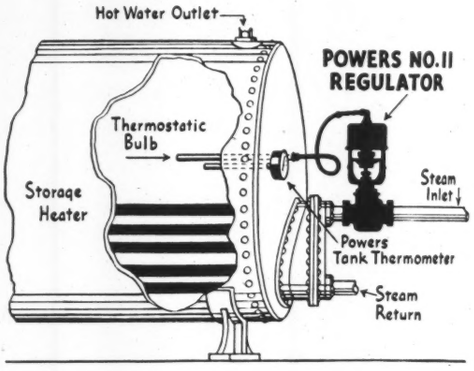
Water Heaters (Heated by Steam or Hot Water) Self-operated regulators, compressed air and water operated regulators, for all types of Storage, Instantaneous, or Submerged Heaters.

Hot Water Line Control Regulators for mixing hot and cold water to deliver a mixture at a predetermined temperature.

Mixing Steam and Water—Regulators to mix steam and cold water or steam and warm water to deliver a mixture at a predetermined temperature.

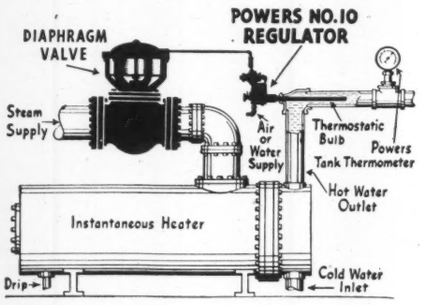
Drinking Water Cooling by regulating circulation of brine or other refrigerants.

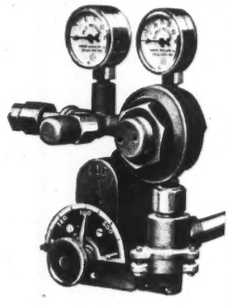
Sprinkler Tank Heaters—Regulators to eliminate freezing and prevent over-heating of water in fire protection systems



Above: Typical Application Self Operating Regulator

Below: Typical Application of Powers Compressed Air or Water Operated Regulator





Use Powers Control for—

INDIVIDUAL SHOWER BATHS—Most complete line of thermostatic safety water mixing valves for showers, tub and shower combinations, ring and rose showers, etc.

GROUP AND GANG SHOWERS—Mixing valves for showers in groups of 4 to 20 baths.

ZONE SHOWERS—Progressive lane showers for swimmimg pools.

HOSPITAL HYDROTHERAPY—For arm and leg baths, douche baths, colonic irrigation, control tables, continuous flowing baths, etc.

INFANT BATHS—For maternity wards.

SURGEONS WASH-UP SINKS—Knee and Elbow operated mixers.

X-RAY PHOTOGRAPH DEVELOPING BATHS—Mixing valves to accurately maintain proper temperatures.

INDUSTRIAL PROCESSES — Most complete line of mixing valves, made with capacities of from 2 to 2500 gals. per minute, used for Bakery Dough Mixing Machines, Sausage casing washing, oil drum washing and hundreds of other operations.

LOCOMOTIVE BOILER WASHING—Regulators for hot water used in washing out boilers and sludge dumping; also for washing down outside of locomotive.

WASH SINKS—To prevent overheated water.

SHAMPOO FIXTURES—For barber shops—beauty parlors.

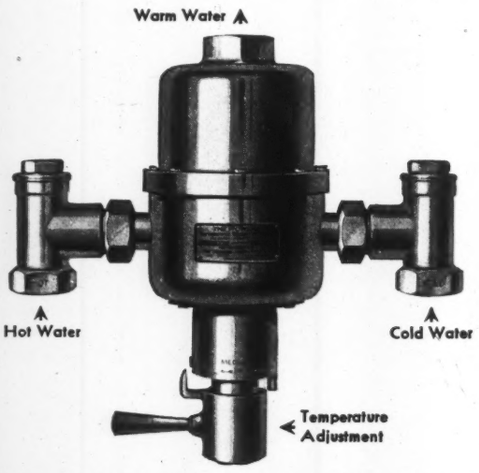
WASHING AUTOS, TRUCKS & BUSES—Mixing Valves for hot and cold water and steam and cold water.

LAUNDRY WASHWHEELS—For washing woolens, silks and colored goods.

DISHWASHING MACHINES—For large machines used in Hotels, Restaurants, Clubs and Hospitals.

BOTTLE WASHING MACHINES for Dairies and Beverage Bottlers.

Below: Powers Thermostatic Water Mixing Valves



ENGINEERING SERVICE—No other firm can offer you the wealth of experience gained by Powers engineers in providing water temperature control for every conceivable purpose in all types of buildings and industries; and no other firm can offer you as large a variety of controls—only a few of our simplest types are shown here. Whenever you have a problem of water temperature control call in a Powers engineer. His recommendations may save you considerable time and help you to get the best type of control for any particular purpose.

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THE EDITOR'S PAGE

AIR conditioning is involved in an unusually high percentage of proposed loans under the $50,000 amendment to the National Housing Act, it is believed. Of twelve applications in one state which came up for approval recently, two were for the purchase of air conditioning equipment. . . . When it is realized that proceeds of modernization loans may be used for over 150 purposes, the importance of air conditioning in the modernization of plants and buildings as indicated by the above ratio is quickly apparent.

Federal Housing Administration business passed the $400,000,000 mark last month, the FHA reports, Title I modernization and repair notes insured accounting for over $185,000,000. This is all private capital, as the Administration does not loan money. . . . From available statistical sources and reports, the FHA estimates that since launching of its modernization and repair program, more than $900,000,000 of this type of work has been done, as it is thought five to six dollars is spent for each one dollar obtained through an insured loan. . . . Every important indication points to an increased volume in practically every class of building and engineering work in 1936, according to a forecast report by the F. W. Dodge Corp.

In announcing its term-payment purchase plan to enable purchasers of its products to take advantage of the amended National Housing Act, Worthington Pump and Machinery Corp. points out that neglected opportunities for savings in any industrial plant are equivalent to direct losses, and that such losses can be avoided by modernization. It is not generally understood by users of industrial equipment, says Worthington, that the amended act enables purchase of needed equipment, apparently because of the emphasis on the word "housing" in references to the act and the FHA. . . . As distinguished from the earlier modernization loans limited to $2,000, the $50,000 credit ruling makes possible, in addition to modernization, alterations and repairs to property, the purchase and installation of any machinery or equipment that comes under the classification of being necessary to the conduct of the business or institution taking out the loan. . . . Business men should launch an "economic new deal" of their own by rebuilding America, Clarence Francis, General Foods' executive vice-president, told the national sales executives' conference in New York last month. Far too many commercial and office buildings, factories, schools, hotels and public institutions are antiquated, run-down, far too costly to maintain, he said, and predicted we are on the verge of a sellers' market.

A 20 per cent gain in commercial building, 20 per cent more industrial building, and a 10 per cent increase in institutional building for 1936 over 1935 were predicted by Russell G. Crevistón of Crane Co. at the Central Supply Association meeting last month.

The chemists and engineers composing the coroner's jury which investigated the soy bean processing plant explosion in Chicago early last month recommended that the city formulate rules and regulations for providing pressure relief, adequate ventilation, and systematic testing of air for dangerous mixtures in manufacturing plants where hazardous air mixtures are likely to exist. Cause of the explosion was not determined by the jury; Fire Chief John E. Murray, fire chemistry expert, stated in a report his belief that the blast was caused by spontaneous eruption of dust in a large bean meal residue tank, suggested, among other things, installation of humidifying equipment in the hexane division of such plants.

W. H. Carrier is soon to embark upon an extensive tour to survey air conditioning progress in a number of foreign lands, including South Africa, India, Siam, Java, and the Philippines, possibly Australia and New Zealand. . . . He has promised to outline his impressions in a series of articles to be published in HEATING, PIPING AND AIR CONDITIONING; upon his return he will present a paper on the economics of deep mine air conditioning before the A. S. H. V. E. based on first-hand studies of the Robinson deep gold mine on the Rand. . . . Expansion of the research facilities of the Owens-Illinois Glass Co. was announced last month following award of a contract for construction of a two story all glass laboratory building in Toledo. To be built entirely of glass blocks, the building is to be air conditioned, will have a roof insulated with glass wool. . . . A signal system for indicating outdoor weather conditions is to be installed in the windowless, air conditioned office building of the Hershey Chocolate Corp. Three colored glass, electrically lighted, bull's eyes on a panel in each office will show by seven different combinations of red, white and green if the weather is clear, cloudy, rainy, sleeting, snowing, clear below 10 F, or clear above 90 F. . . . That's putting the weather in its place. . . . Twenty-fifth anniversary of the bakelite industry is being commemorated this month and the Bakelite Corp. has issued a special edition of its house magazine.

Standards for testing and rating unit air conditioning equipment, prepared by a joint committee, were adopted unanimously by the Air Conditioning Manufacturers' Association at its meeting last month. . . . First in a course of lectures on the fundamentals of metallurgy as applied to welding was given before the Chicago section of the American Welding Society last month; the course is to run through the fall and winter season. . . . The November 14 afternoon session of the International Acetylene Association's annual convention at Cleveland will be devoted to welding piping and pressure vessels, will include papers on high pressure piping, by J. A. Freiday, Thomas J. Murray, Inc.; welding Class I pressure vessels, by G. W. Plinke, Henry Vogt Machine Co.; welded piping and pressure vessels in the marine field, by J. W. Wilson, Bureau of Navigation and Steamboat Inspection; and permanency of oxy-acetylene welding, by F. C. Hutchison, Linde Air Products Co. . . . The American Standards Association has adopted as an American Standard the report of its sectional committee on threads for hose connections having nominal inside diameters of ½, ⅝, ¾, 1, 1¼, 1½, and 2 in. (ASA B33.1-1935).

Charles F. Scott, professor-emeritus of electrical engineering, Yale University, was elected chairman of the Engineers' Council for Professional Development last month, succeeds Dr. C. F. Hirshfeld, Detroit Edison's chief of research. . . . John Everetts, Jr., is offering an evening course in air conditioning under the auspices of the university extension division of Columbia University, New York City.

Among the papers to be presented at the annual meeting of the *American Society of Refrigerating Engineers* next month are: "Data from Experiment and Research Preceding the Construction of Large Freon Compressors," Llewellyn Williams; "The Calculation of Evaporator Surfaces for Air Conditioning," F. H. Faust; "Investigations of the Health Aspect of Air Conditioning," Dr. W. J. McConnell; "The Control of Odors," Philip Drinker; "Safety in Air Conditioning," Dr. C. S. Cragoe; "Specifications for Air Conditioning," E. W. Goodwin; "Proposed Standards for Rating and Testing Air Conditioning

[*Continued on page 96, back section*]

A GREATER REPUBLIC STEEL CORPORATION

accepts the challenge of industry . . .

With assets increased by more than $40,000,000, with greatly enlarged reserves of northern iron ores, with advantageous terminal facilities on the Great Lakes and strategically located additional plants, a greater Republic Steel Corporation accepts the challenge of every steel-using industry.

The merger of Corrigan-McKinney Steel Company and Newton Steel Company with Republic Steel Corporation is one of far-reaching significance. Corrigan-McKinney Steel Company brings to Republic tremendously increased facilities for the production of high grade pig iron and steel. Newton Steel Company has long been an important source of supply for quality sheets.

Even before the acquisition of these companies, Republic was the world's largest producer of alloy steels, including the famous Agathon line, ENDURO perfected stainless steels and the new Republic Double Strength high tensile steels that are lightening the weight of nearly every type of transportation unit. Republic has been the sole maker of rust-resisting Toncan Iron for more than 27 years—the pioneer in the development of electric resistance welded pipe—the maker of Sil-con low-loss electrical sheets and coiled strip.

In addition to making these trade-marked products, Republic continues to occupy an important place among the producers of high quality plain carbon steels in practically all commercial shapes.

A greater Republic Steel Corporation accepts the challenge of industry —looks optimistically to the future—keeps pace with the increasing demand for ever better steels—steels lighter in weight—steels of greater strength—steels more resistant to corrosion and high temperatures—steels that strike a new note in beauty—steels more dependable, longer lasting and more economical.

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BARS AND SHAPES • PLATES
HOT AND COLD ROLLED STRIP
HOT ROLLED, COLD ROLLED
AND SPECIAL FINISH SHEETS
TIN PLATE • WIRE PRODUCTS
NUTS, BOLTS, RIVETS, ETC.
DIE ROLLED PRODUCTS

Heating · Piping and Air Conditioning

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CONTENTS *for* NOVEMBER, 1935

Vol. 7, No. 11 Pp. 513-564

Persistent Conservation Efforts Cut Steam for Heating in Half, by Lyman R. Flook 513

Alteration of Pumping Equipment 517

Commercial Air Conditioning Jobs Predominate, Report Shows 518

Railroad Terminal Equips for Air Conditioning 518

How to Use Reynolds Numbers in Piping Calculations, by Max W. Benjamin 519

Air Conditioning Modernizes Office Building, by S. L. Rolland 524

Method of Steam Jacketing Piping for Handling Heavy Oil, Tar, by G. W. Hauck 527

Metallic Pipe Insulation 527

A Problem in Trouble Shooting, by William Goodman 528

Specifications for Radiographic Examination of Steel Castings for Piping Service, by Herbert R. Isenburger 530

Heat Balance Analysis for Air Conditioning, by Louis A. Harding 531

U. S. Equipment Air Conditions Montevideo Bank Building, by Rudolf Kuhlmann 533

Resistance of Valves and Fittings to Flow of Fluids 534

Practical Heating, by Harold J. Taylor 535

Air Conditioning for Motor Buses Announced; System Described 537

Handling Fuel Oil from Tank Car to Burners, by Kalman Steiner 538

Chicago Air Conditioning Standards Ready; Results Emphasized 539

Equipment Developments (back section) 86

Conventions and Expositions (back section) 96

Booklets, Reports and Papers (back section) 100

Recent Trade Literature (back section) 102

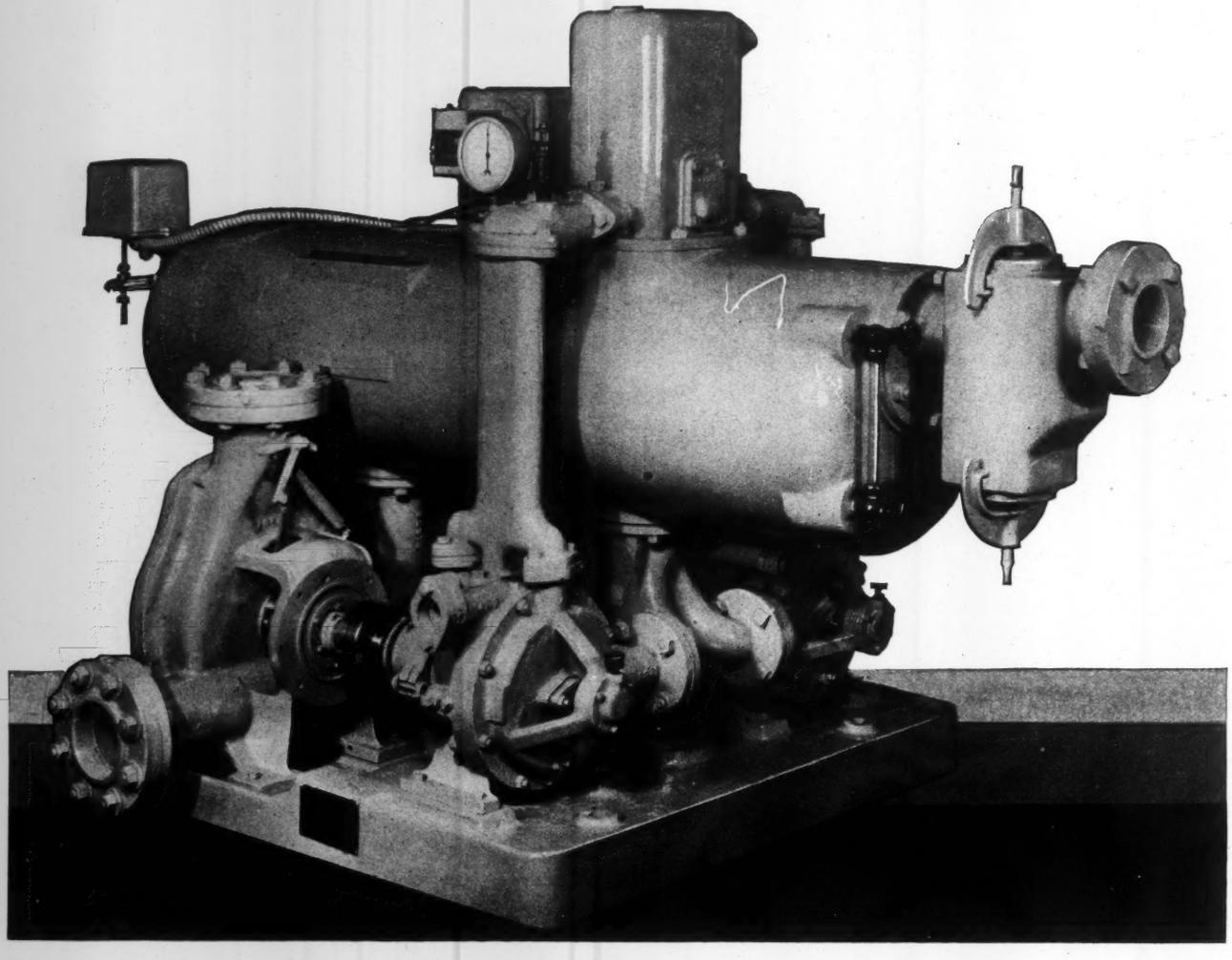
Index to Advertisers (back section) 108

Journal Section of the American Society of Heating and Ventilating Engineers

Comfort Standards for Summer Air Conditioning, by F. C. Houghten and Carl Gutberlet 543

Subjective Reactions of Human Beings to Certain Outdoor Atmospheric Conditions, by C.-E. A. Winslow and L. P. Harrington 551

Bulletin Section 557



THIS NEW NASH STEAM OPERATED PUMP CUTS RETURN LINE HEATING COSTS.

This remarkable Return Line Heating Pump requires no electric current, eliminating the greatest expense item in the operation of any ordinary pump. The motive power is a special turbine. It operates on any heating system, above or below atmosphere.

The steam which operates the turbine passes directly back to the heating mains with little heat loss. None is wasted.

But the really important saving effected by the Vapor-Turbine is in the system, for the reason that this pump operates continuously. It is the only pump that can do this with economy. Continuous operation means uniform circulation, and uniform circulation saves steam. Owners report remarkable savings in fuel with the Vapor-Turbine.

Mechanically, this pump is a marvel. One moving element, no wearing parts, no interior lubrication. Compact, trouble-proof.

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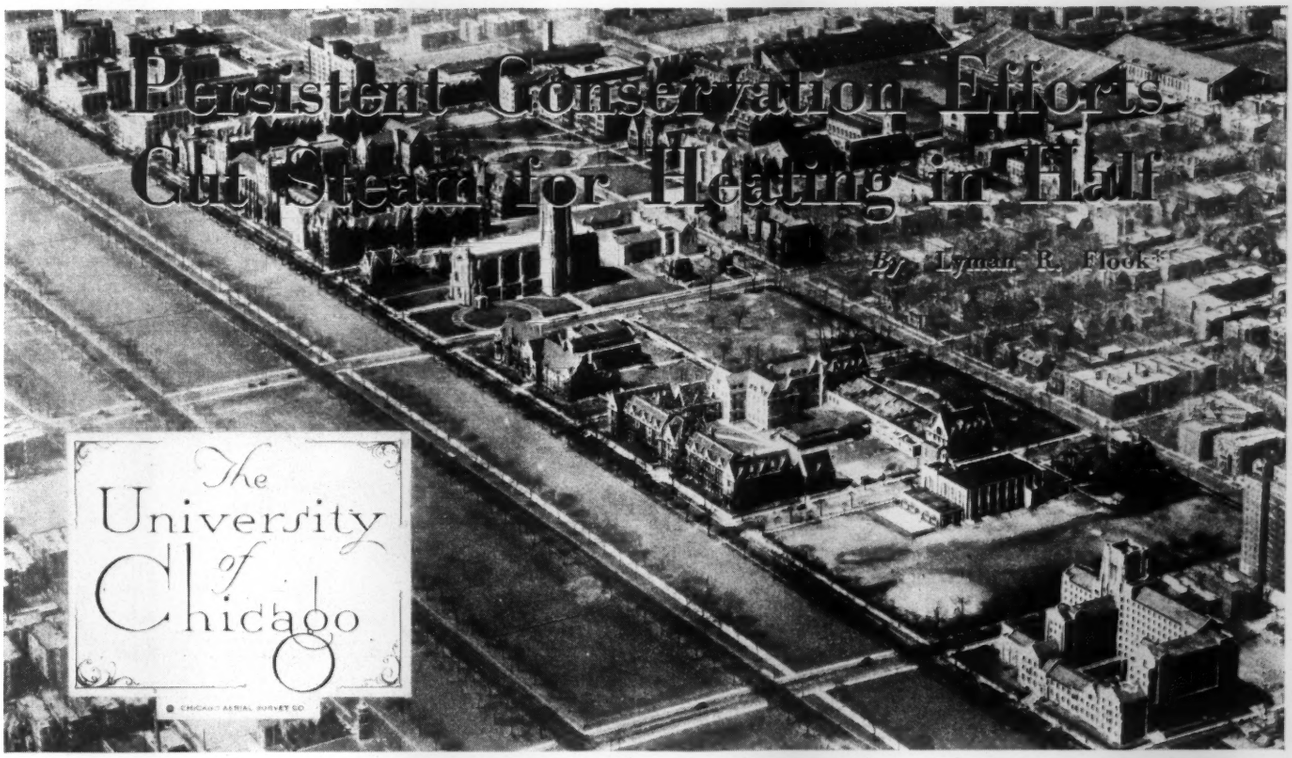
Heating · Piping and Air Conditioning

Vol. 7, No. 11 • *November, 1935*



Persistent Conservation Efforts Cut Steam for Heating in Half

By Lyman R. Flook[1]

THE heating system serving a building or group of buildings can be a source of aggravating difficulties and dissatisfactions, or it can be a source of great satisfaction and can contribute materially to the effectiveness of a plant, building or institution. The prime objective must always be perfection of service, with economy highly important but secondary to it. Heating costs at The University of Chicago have been sharply reduced during the past few years, while service has been improved and plant facilities have been put in better condition. How this has been accomplished is our subject here, as the methods used should be of general interest in that they will serve to indicate similar possibilities to others.

At the University—which occupies some hundred acres of city property eight miles south of Chicago's loop—heating is a part of physical plant expense administered by the department of buildings and grounds, and responsibility for the operation of the service rests upon the superintendent of buildings and grounds. Generation and transmission of steam is under the supervision of the chief engineer, while steam distribution and utilization is under the foreman steamfitter.

During the past ten years an obsolete heating plant has been eliminated, a new and modern boiler plant at a railroad site has been built, and new, unusually long tunnels for steam transmission have been constructed.[1] Extensive alterations have been made in the old and partially worn out distribution system and older buildings have been renovated with particular regard to the steam piping, where many gravity systems have been converted to vacuum. Windows have been caulked and weatherstripped. Old buildings have been equipped with various types of control. Pipe covering has had special attention.

In the recent construction program, particular attention has been given design and arrangement of steam using facilities in new buildings to assure economy in op-

[1]Superintendent of Buildings and Grounds, The University of Chicago; formerly, Superintendent of Buildings and Grounds, the University of Michigan.

[1]See "Central Steam Plant and Pipe Tunnels Keep Heating Costs Down at U. of C.," by Charles Levin, HEATING, PIPING AND AIR CONDITIONING, February, 1933, pp. 90-93.

A well planned, persistently carried out steam conservation program at the University of Chicago has reduced consumption from 2.698 to 1.208 lb per degree day per 1000 cu ft of space.... To achieve results such as this, much preparation is required and continual pressure throughout the year is needed to accomplish the maximum possible result, as is the hearty cooperation of many persons....How it was done—and how others can do likewise—is told here

erating costs, and many buildings have been generously insulated. Types of construction have been chosen with low operating cost in mind. Dual thermostats, master control, and high vacuums have been used with success. Automatic clock controls and similar devices have been provided to reduce the work required to operate complex apparatus.

Steam Carefully Metered

The question of measurement of results for better control of operations has had intensive study. One hundred and nineteen steam meters (Table 1) enable the measurement of heating steam almost as effectively as electricity is metered. Steam meters are read regularly and bills for steam service are rendered monthly; for check, many of the meters are read twice each month.

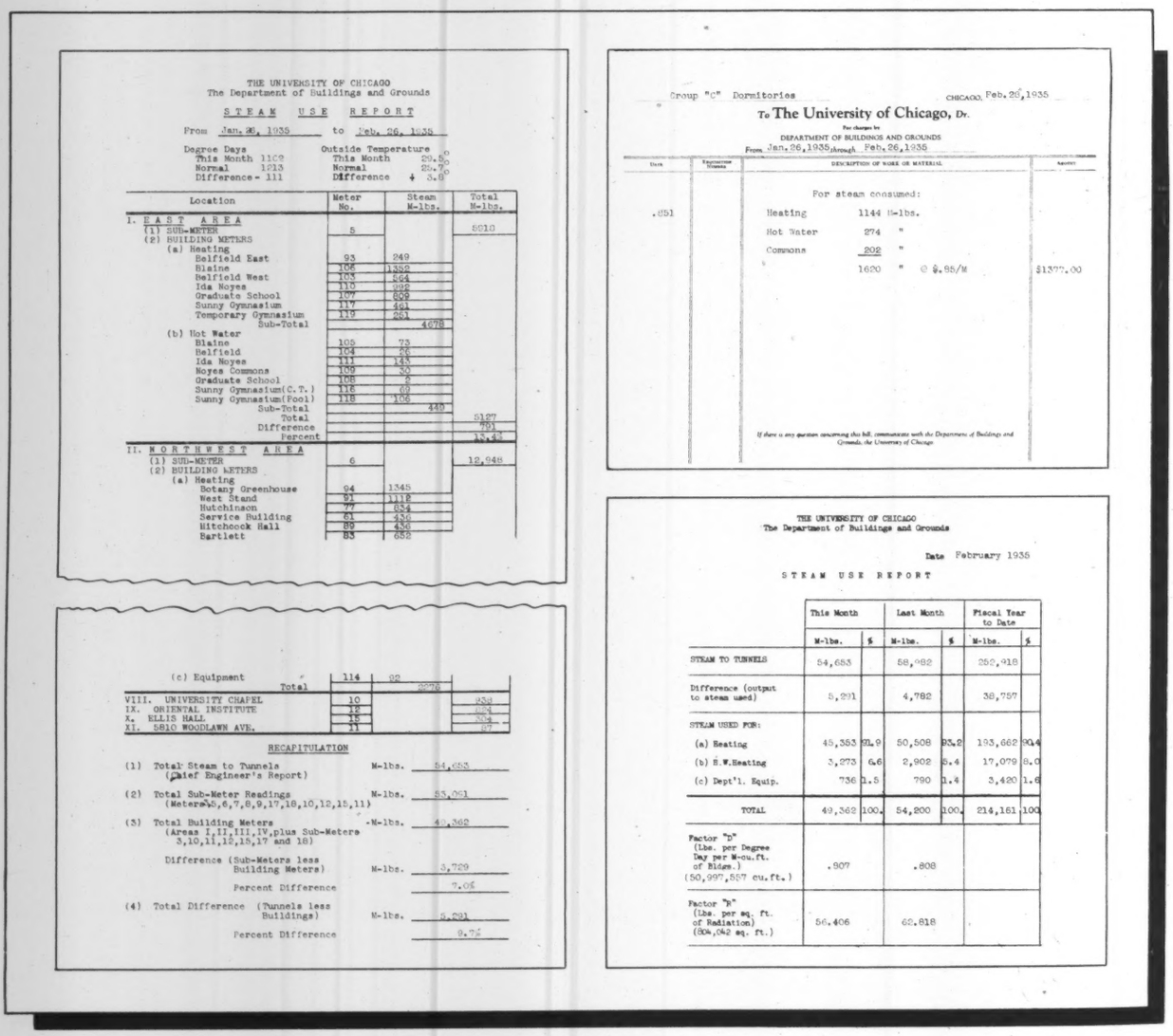
All meters are serviced and tested for accuracy regularly, each meter being taken out once a year for complete calibration in our own meter testing laboratory. Through the chief engineer, specialists inspect, adjust and check these meters so that now, after a period of three years in which the load has been similar, abundant data are available for firm reliance on steam meter readings.

The monthly steam reports (the master reports) indicate the use of steam for each building for each purpose for the period. Each monthly bill bears a factor denoting the pounds of steam per degree day per month per 1000 cu ft. of building space. These factors arranged monthly give very good control; those receiving the bills have the previous month's bill and the same month's bill of the previous years, and knowing the variation in use

Table 1—Types of Meters in Service at University of Chicago

STEAM METERS	
Flow type	
Shunt	
Mechanical (46 2-in.; 2 3-in.; and 4 4-in.)	52
Orifice	
Electrical	15
Mechanical	5
CONDENSATE METERS	
Displacement	
Rotary	41
Disc	1
Propeller	2
Trap Type	
Float	2
Tilt	1
TOTAL	119

Fig. 1—Steam use report forms and bill for steam which is rendered monthly. These forms aid department of buildings and grounds at the University of Chicago in achieving heating economies



THE UNIVERSITY OF CHICAGO
The Department of Buildings and Grounds

STEAM USE REPORT

From Jan. 26, 1935 to Feb. 26, 1935

Degree Days: This Month 1102, Normal 1213, Difference - 111
Outside Temperature: This Month 20.5°, Normal 29.7°, Difference + 3.8°

Location	Meter No.	Steam M-lbs.	Total M-lbs.
I. EAST AREA			
(1) SUB-METER	5		5010
(2) BUILDING METERS			
(a) Heating			
Belfield East	93	249	
Blaine	106	1382	
Belfield West	103	564	
Ida Noyes	110	992	
Graduate School	107	809	
Sunny Gymnasium	117	461	
Temporary Gymnasium	119	261	
Sub-Total		4678	
(b) Hot Water			
Blaine	108	73	
Belfield	104	26	
Ida Noyes	111	143	
Noyes Commons	109	30	
Graduate School	108	8	
Sunny Gymnasium(C.T.)	116	62	
Sunny Gymnasium(Pool)	118	106	
Sub-Total		448	
Total			9127
Difference			781
Percent			15.42
II. NORTHWEST AREA			
(1) SUB-METER	6		12,948
(2) BUILDING METERS			
(a) Heating			
Botany Greenhouse	94	1345	
West Stand	91	1118	
Hutchinson	77	634	
Service Building	81	436	
Hitchcock Hall	89	436	
Bartlett	85	652	
(c) Equipment	114	82	
Total		8276	
VIII. UNIVERSITY CHAPEL	10		958
IX. ORIENTAL INSTITUTE	12		863
X. ELLIS HALL	15		904
XI. 5810 WOODLAWN AVE.	11		87

RECAPITULATION

(1) Total Steam to Tunnels (Chief Engineer's Report)	M-lbs.	54,683
(2) Total Sub-Meter Readings (Meters 5,6,7,8,9,17,18,10,12,15,11)	M-lbs.	50,951
(3) Total Building Meters (Areas I,II,III,IV,plus Sub-Meters 3,10,11,12,15,17 and 18)	M-lbs.	40,362
Difference (Sub-Meters less Building Meters)	M-lbs.	3,729
Percent Difference		7.0%
(4) Total Difference (Tunnels less Buildings)	M-lbs.	9,231
Percent Difference		9.7%

Group "C" Dormitories CHICAGO, Feb. 26, 1935

To The University of Chicago, Dr.

For charges by
DEPARTMENT OF BUILDINGS AND GROUNDS
From Jan. 26, 1935 through Feb. 26, 1935

Date	Engineer Weeks	DESCRIPTION OF WORK OR MATERIAL	Amount
		For steam consumed:	
.051		Heating 1144 M-lbs.	
		Hot Water 274 "	
		Commons 202 "	
		1620 " @ $.85/M	$1377.00

If there is any question concerning this bill, communicate with the Department of Buildings and Grounds, the University of Chicago

THE UNIVERSITY OF CHICAGO
The Department of Buildings and Grounds

Date February 1935

STEAM USE REPORT

	This Month		Last Month		Fiscal Year to Date	
	M-lbs.	%	M-lbs.	%	M-lbs.	%
STEAM TO TUNNELS	54,683		58,982		250,918	
Difference (output to steam used)	5,291		4,782		38,757	
STEAM USED FOR:						
(a) Heating	45,383	91.9	50,508	93.2	193,662	90.4
(b) H.W.Heating	3,273	6.6	2,902	5.4	17,079	8.0
(c) Dept'l. Equip.	736	1.5	790	1.4	3,420	1.6
TOTAL	49,392	100.	54,200	100.	214,161	100.
Factor "b" (Lbs. per Degree Day per M-cu.ft. of Bldgs.) (50,997,807 cu.ft.)	.907		.808			
Factor "b" (Lbs. per sq. ft. of Radiation) (804,042 sq. ft.)	56.406		62.818			

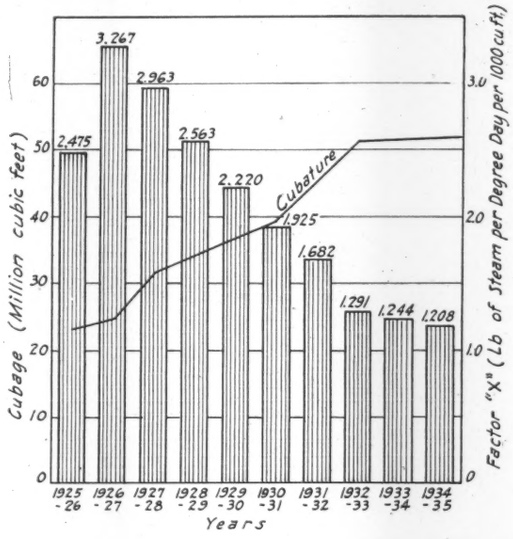


Fig. 2—Reduction in steam consumption, 1925-35

Table 2—Summary of Operation for Ten-Year Period

Year	Cubage	Tons Coal Burned	M-lb Steam Output	Factor "X"
		Old Plant		
1925-26	23,189,040	26,485	395,769	2.475
1926-27	24,618,469	34,308	483,646	3.267
1927-28	31,420,521	33,854	562,589	2.963
				2.902[a]
1928-29	34,104,104	31,489	535,146	2.563
1929-30	36,608,922	33,708	513,515	2.220
				2.698[b]
		New Plant		
1930-31	39,232,132	31,931	456,824	1.925
1931-32	45,519,206	28,526	401,462	1.682
1932-33	50,997,557	27,940	402,896	1.291
1933-34	50,997,557	27,027	386,441	1.244
1934-35	50,997,557	27,534	385,656	1.208
				1.470[b]

[a] Average of three years.
[b] Average of five years.

or occupancy of the building can at once have a very good indication as to whether or not too much steam is being used and where effort should be made to reduce it.

Steam Conservation a Fascinating Problem

Conservation of steam is a fascinating problem. Prompt, reliable records are half the job; the balance is personal and ordinarily depends upon the enthusiasm of some few people who are actively in contact with the problem and alert to beat former records. Our conservation effort takes the form of regular inspections and reports with recommendations by a small committee ordinarily headed by the chief engineer with whom is associated the steamfitter foreman, or the local engineer. This small group makes inspections with the local administrator, the hospital superintendent, the manager of the cafeteria, or the dormitory housekeeper, whose cooperation must, of course, be close and enthusiastic.

After the primary inspection, the committee makes a series of recommendations which will ordinarily be that the steam is to be shut off and turned on at specific hours of the day, varying with the season. Secondly, the inspection usually indicates wastage through excessive radiation, windows open in unoccupied rooms, outside doors left open, piping not well insulated, needed changes in the hours of operation of the ventilation units, poor circulation in the system, lack of efficient control of hand valves, and lack of frequent checks at thermometers at various parts of the building—particularly in mild weather, when overheating should be avoided. A heating plant is scarcely ever wasteful in severe weather, for on cold days all of the radiation operating at designed capacity is required. It is during the spring and fall months and mild winter days that waste occurs. This waste is roughly inversely proportional to the number of degree days for the month.

The committee also makes justifications where its recommendations involve expenditures; that is, the improvement must pay out in a very short time, usually in not more than three years, at the bare cost of fuel only, for the extra cost or the saving results only from the fuel costs since the service must be maintained in any case.

It is customary to inspect each building at least four times a year, beginning in October when school opens and, not ceasing in June when the heating season is over, but continuing through the summer months when large quantities of steam are used for non-heating purposes. Since about 70 per cent of the total steam output is used for heating, the major savings can of course be made during the winter.

Ten Year Tabulation of Steam Consumption

A ten year tabulation of the Factor "X" is given in Fig. 2 and Table 2. It will be observed that cubage increased very rapidly from 23 million in 1926 to 51 million cu ft in 1935. Despite this enormous increase, the unit consumption of steam has been steadily reduced. Figures for 1926-27 were unusually high for two reasons; first, because of the over-loading of the old plant; and second—and more important—because of wastage of steam on a large construction project which was boarded up for temporary heating. Averaging the first three years of Table 2, however, gives a fair indication of the usage of the old plant. Averaging the five years ending in 1929-30 gives a very good figure for the efficiency of the old system, building and plant combined, at 2.698 lb of steam per degree day per 1000 cu ft of building space.

The new Blackstone avenue boiler plant took the load in November, 1929, but steam was sent 6000 ft to the old generator during that winter, so that the earlier figure included generation where exhaust steam was sent to the buildings for a part of the electric load only. Generation of electricity was discontinued in August, 1930. The figures for the new plant for the past five years show an average of 1.470 lb of steam for Factor "X," which is 50.7 per cent of the average of the previous five years with the old plant and the old building. This reduction in unit steam consumption is even better for the past year where the low figure of 1.208 has been reached.

During this ten year period the program of steam conservation was effectively in operation to renovate old facilities, adding new and more efficient buildings, but more important, particularly since 1930-31, has been the

effort of actual conservation. The reduction in steam delivered to the tunnel from 535,146,000 lb in 1928-29 to 385,656,000 lb in 1934-35 is almost entirely due to the unceasing pressure for economy in this operation. The reduction in coal consumption from 32,000 tons in 1930-31 to 27,534 tons during the past year is also almost entirely due to conservation efforts and very largely represents the effect of closer supervision. During this period, and especially during the past year, there have been increases in use such as greater occupancy in dormitories, more meals served in dining rooms, and more patients in hospitals. Normally the steam requirements should be larger, but the only reflection of this greater use is a small increase in the fuel consumption for the past year.

It has been found that Factor "X" is a very reliable and consistent unit, particularly for the colder months when the degree day total is large. This factor for the warmer months, the degree day total being used as a divisor, is of course not as reliable. However the actual meter readings have proved most important. Our people have long since ceased questioning meter readings or the accuracy of the steam bills, a difficulty encountered when the billing was first started. We are satisfied that meter readings are within 2 per cent of the facts, and our efforts now are to make marginal savings where the cost must be justified over a longer period of years, or upon some other basis, such as replacement of a worn facility, old piping, rerouting to use smaller piping, better covering and the like.

A mass of data has been accumulated covering separate buildings of different types. In addition to the bare assembling of meter readings it is our custom to group buildings of a like type for analysis. It has been found that the data represent known variations in use, construction, or exposure, and that the same reliability can be placed upon steam meter readings as one is accustomed to accept from electrical, gas, or water meter readings.

Reducing the Peak Steam Load

Another interesting result of this work has been the study of the load duration curve, reproduced as Fig. 3. It will be observed that the plant has a considerably greater capacity than the present peak. The plant was projected during a program of building construction which was planned, like many other universities, with an over-generous provision for the future, estimating a steam load of 339,900 lb of steam per hr peak for the year 1944-45 and for the year 1935-36 a maximum of 280,200 lb per hr.

Those estimates were based upon 1928-29 conditions, before the time of better construction of the buildings, more insulation, better control devices, particularly the wider use of the more expensive of these control devices, all of which have had the effect of greatly reducing the peak load. Under pressure of necessity during recent years, it has also been possible to manipulate the system so as to reduce the peak load. One of the most interesting phases of this subject is the fact that the peak load for the past three years has not exceeded 150,000 lb per hr. There were no additions to cubage during the past two years so that the reduction in peak load represents pretty largely the efforts of conservation. It was found possible to stagger the peak loads of individual buildings which had previously occurred simultaneously, particularly in the heavy winter weather, men were ordered out to turn steam on earlier, and the point of the peak load was stretched out over a wider area, thus greatly reducing its magnitude. This procedure might very well be adopted by many institutions where peak loads seem to require additional boiler facilities.

The load factor of a heating plant is notoriously poor; figuring the peak load of the year 1930-31 at 171,000 lb of steam per hr the load factor was but 33.1 per cent. Figuring the peak load of 1934-35 at the reduced amount of 138,000 lb of steam per hr the load factor was 36.1 per cent. From this curve it is observed that the hours of maximum load have been reduced while the hours of average heavy load have remained steady and the hours of the boiler load have been curtailed.

Loss in Transmission of Steam

We are frequently asked about the loss in transmission of steam. Our figures permit no direct comparison,

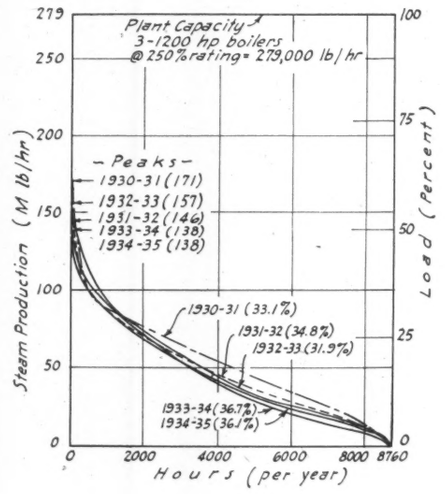
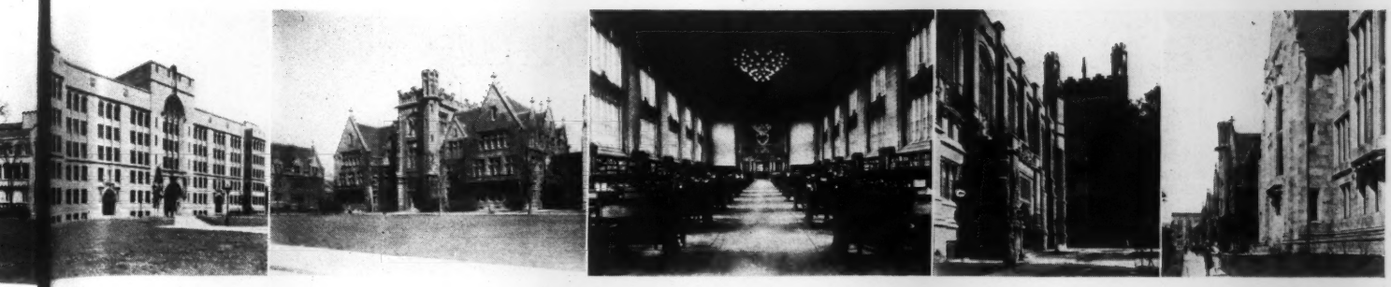


Fig. 3—Load duration curves for past five years; the percentage figures are load factors



Some of the seventy-six major buildings at The University of Chicago

Left to right—University Chapel (1928)—Some direct radiation, but heating combined with ventilation and recirculation; thermostatic control. . . . . Hutchinson Hall (1902)—Large dining room, wood roof, hot blast heating; thermostatic control, some direct radiators. . . . . Harper Memorial Library (1916)—One pipe steam converted to vacuum system. Large reading room heated by hot blast system, recirculation ducts provided for quick heating. . . . Home for Destitute Crippled Children (1928)—Vacuum steam heating; thermostatic control. . . . . Chicago Lying-in Hospital (1931)—Vacuum steam heating system with thermostatic control. . . . . Physiology Building (1927)—Roof insulated. Hot water system, automatic control. . . . Ryerson Physical Laboratory (1896)—Work of three Nobel prize winners—Michaelson, Millikan and Compton—was done in this building. Wood roof, one pipe steam system; thermostatic control. . . . . Harper Memorial Library, Main Reading Room—Hot blast system, tile ceiling, leaded glass windows. Very difficult to heat. Hot blast system is recirculated in order to accomplish warming up in a short period. . . . . Law School (1903) and, rear, Harper Memorial Library—Hot blast system, thermostatic control, wood roof. . . . . Eckhart Hall (1930)—A recent building. Pre-cast roof with insulation, dual thermostats. Used for research laboratories in physics and mathematics. . . . . (Lying-in Hospital, Physiology Building, Ryerson Laboratory, and Harper Library interior photos by Capes.)

but we can tabulate figures which give a very good indication. Steam is metered as it enters the tunnel of the transmission system at the wall of the boiler plant. It is again metered as the transmission system is joined by the distribution system where master meters permit of check readings. The sum of all of the building meters can then be separated into groups, each group of building meters again to individual group meter, and the sum of the group meters can be compared with the readings at the boiler plant.

Table 3 indicates, for the past four years, the differences between the steam measured at the entrance to the tunnel and the total of the distribution meters and the building meters. The transmission line is new, well covered and highly efficient. The distribution system consists of connections to piping in old tunnel; in many of the lines the direction of flow is reversed, and pipe sizes are too large because of use of old low pressure lines. In addition the figure represents as well steam not returned, where for example steam is turned into soil beds in a greenhouse, where it is used in direct contact with cold water at the faucets in one building to produce hot water, etc.; steam which does not return to the boiler plant but is lost insofar as the building meters are concerned. In addition, these figures are all-inclusive, taking in all discrepancies of meter readings and errors. In spite of these limitations, the figures in Table 3 may be of interest as showing what these "losses" amount to.

It will be noted that the figures show great improvement. It will also be noted that the improvement is at a decreasing rate. It should be borne in mind, however, that these are percentage figures. As the total amount of steam used decreases, the per cent required to heat the transmission and distribution system becomes more significant. Very soon one is paying a penalty for large pipe sizes and provisions for future growth.

Table 3—Metered Steam, Annual Variations

	1931-32	1932-33	1933-34	1934-35
Transmission System[a]	3.9%	4.2%	5.9%	5.1%
Distribution System[b]	16.2	15.0	12.4	12.1
Both[c]	20.1%	19.2%	18.3%	17.2%

[a] Steam into tunnels at boiler plant wall less steam measured at end of transmission lines.
[b] Steam into distribution system less steam measured by building meters.
[c] Steam to tunnels less steam measured by building meters.

Alteration of Pumping Equipment

Alteration of existing equipment to meet some new special need is a problem that is likely to arise in practically any industry. Pumping systems, particularly, are often subject to such modifications.

Oxy-acetylene welding and cutting provide a means by which alterations can frequently be made without inconvenience and loss of time, at a minimum of expense. For example, in the rehabilitation of an old brewery it was found advisable to have an additional source of water supply for emergency use. This was to be provided by a reserve tank on the roof of the building. In order to make the two sources easily interchangeable, the check valve on the water pump was altered in a unique fashion. The cast iron valve cover was removed, a hole cut with a cutting blowpipe, and a section of pipe bronze-welded into this opening. With the check valve altered in this way, water can be taken either from the overhead tank or directly from the pump, using the same main riser in the building.

Another example of the ready alteration of such equipment occurred at a southern orange grove where necessity for additional irrigation required that the pumping systems be changed. To provide the added power, a four-cylinder automobile motor was hooked up to a 400 gpm pump. No special fittings were required to complete this installation, as all of the connections and elbows were fabricated on the spot by use of the cutting and welding blowpipe and permanently watertight joints were assured by bronze-welding.

Commercial Air Conditioning Jobs Predominate, Report Shows

PREPONDERANCE of commercial air conditioning installations with respect to total number served, connected load, and annual energy sales is quite evident from a summary of air conditioning loads served by fifteen Electric Bond and Share Company associated electric and gas utilities and published in Electric Bond and Share's recently issued air conditioning report to its operating companies for 1934-35. Of a total of 2,874 "personal, commercial and industrial" installations prior and during 1934 listed, 1,153 are commercial; of the total 26,782 connected hp, commercial jobs represent 24,336; and the tons of refrigeration for the commercial installations is given as 12,690 of the total 13,946 tons. Information concerning industrial air conditioning installations in the cities served is not indicative of the extent to which air conditioning is actually employed, it is stated, as perhaps a majority of industrial concerns having installations supply their power requirements from isolated plants and such use of air conditioning is not covered by data accessible to utility company commercial departments.

Totals for the reporting companies were purposely omitted from the report with the feeling that they would conveniently but erroneously lead to calculation of averages, and those given in the first paragraph should not be used for that purpose. With differing climatic and economic conditions in territories served by widely separated companies no conclusions could be drawn from the statistics; neither would total annual sales be indicative of the aggregate for the group, as a bare majority, not including all of the larger operating companies, is represented in the summary.

A few words of caution on the use of air conditioning statistics from utility companies are given in the report. Erroneous conclusions are frequently arrived at through lack of understanding as to the method of classifying particular installations, especially those involving only partial functions. Such errors occur, it is stated, mainly with respect to total number of installations served and average horsepower per installation. Some utilities consider air conditioning to include warm air furnaces with motor driven circulating fans, when equipped with either filters or humidifiers; others take the view that both filtering and humidification must be provided, in addition to fresh air supply and automatic control for temperature (but not humidity). Since the forced circulation fan for an average residence has a ¼ to ½ hp motor, inclusion or exclusion with summer cooling installations equipped with refrigeration will have a marked effect on calculated average connected load. Similar remarks apply to commercial installations, when there are a number of small capacity installations.

Another matter to keep in mind, the report advises, is that probably a majority of industrial air conditioning systems over the country are supplied with power and winter heat from private plants. The extent to which air conditioning is used for industrial process purposes therefore can seldom be judged from utility company statistics. Furthermore, an appreciable number of such jobs are constructed from plans and specifications prepared by industrial consulting specialists and do not appear in installation records accessible to trade groups or the public. In other instances, local purchases of separate pieces of equipment give no indication of intended purpose, for secrecy regarding manufacturing processes is attempted.

It is also pointed out that the Department of Commerce statistics on equipment sales in the heating and ventilating industry are quite inadequate as a barometer of air conditioning; only two items directly identified with air conditioning (fans and air washers) are included, while the remainder apply to heating and a variety of industrial uses. The revised grouping of these figures, which is understood to be in development, is expected to meet a long-felt need.

The report is by no means confined to data on installations served by the companies, but includes sections on air conditioning progress during 1934 and 1935, the popularization of air conditioning, activities of various industry groups, certification and codes, comfort and health conditioning, technical considerations, apparatus developments, and notes on applications. Much of the material has been abstracted from H. P. & A. C., and in a selected bibliography of some 46 articles from over a dozen sources are listed 14 articles which have appeared in H. P. & A. C.

Prepared by W. F. Friend, assistant mechanical engineer, and Louis Elliott, consulting mechanical engineer, this 225 page report represents a real job of summarizing developments and trends in this active field. Unfortunately, it is privately issued and copies are not generally available.

Railroad Terminal Equips for Air Conditioning

With demand for air conditioned passenger cars rapidly increasing, the Washington Terminal Co. is provided for the pre-cooling of cars in the Union depot at Washington, D. C., with a fleet of 21 portable generator sets to charge the batteries and serve as an auxiliary power supply while cars are at a standstill. The units are semi-automatic motor-generator sets consisting of an a-c squirrel cage motor direct connected to a low voltage d-c generator and the necessary control apparatus. Being portable and designed for outdoor service, they are used either in the yards or on the station platform, and with an output of 300 amperes d-c at from 40 to 45 volts have capacity to serve two railway cars at the same time. —*H. S. Orwig.**

*Harnischfeger Corp., Milwaukee, Wis.

How to Use Reynolds Numbers in Piping Calculations

Reynolds "functions" are not necessarily Reynolds numbers

By **Max W. Benjamin***

The "rational method" of calculating fluid flow problems is reviewed with an explanation of how different synthetic functions resembling genuine Reynolds numbers can be used to determine the friction coefficient f . . . Means are presented for finding out which function was used in any of the numerous articles on the subject. Brief analyses of several recent articles are given in order to reconcile the differences between them. Attention is called to the danger of confusing synthetic Reynolds functions with the genuine Reynolds numbers, which are truly dimensionless.

ACCURATE estimate of the friction loss incidental to fluid flow pays good dividends in the design of power and industrial process piping. While rule-of-thumb methods, code rules, and handbook tables usually suffice for determining the pipe sizes of sanitary plumbing and building heating systems, such simple procedure may lead to serious error in process lines, power stations, oil refineries, gas and water distribution systems, and the like where upwards of a million dollars may be invested in the piping of a single job. Here the need for careful analysis of flow conditions, pressure drops and relative pumping costs in choosing the proper pipe size is paramount.

Many empirical formulas have been developed from the results of pressure drop tests made with different individual fluids which, on the whole, yielded better results than the rule-of-thumb rules but still failed to apply for conditions much different from those obtaining on test. There are empirical formulas for steam flow, others for water flow, still others for gas flow, and in years past the calculation of oil flow was anybody's guess, depending upon his particular experience.

The so-called rational method of determining pressure drop using Reynolds numbers which take into account the fluid characteristics of density and viscosity has been widely publicized in recent years. This method deals with properties common to any fluid and pipe line which vary in degree rather than in nature so that pressure drop data acquired through flow tests with one fluid can be equally well applied to the flow of other fluids of known viscosity and density. In this method the properties of fluid density and viscosity are related to pipe diameter and velocity of flow to yield what is called a *Reynolds number*. For each Reynolds number there is one coefficient of friction for a given pipe wall roughness irrespective of the nature of the fluid. This frictional coefficient is used in a formula of the usual type:

$$p = \frac{k f L v^2 y}{D}$$

Where

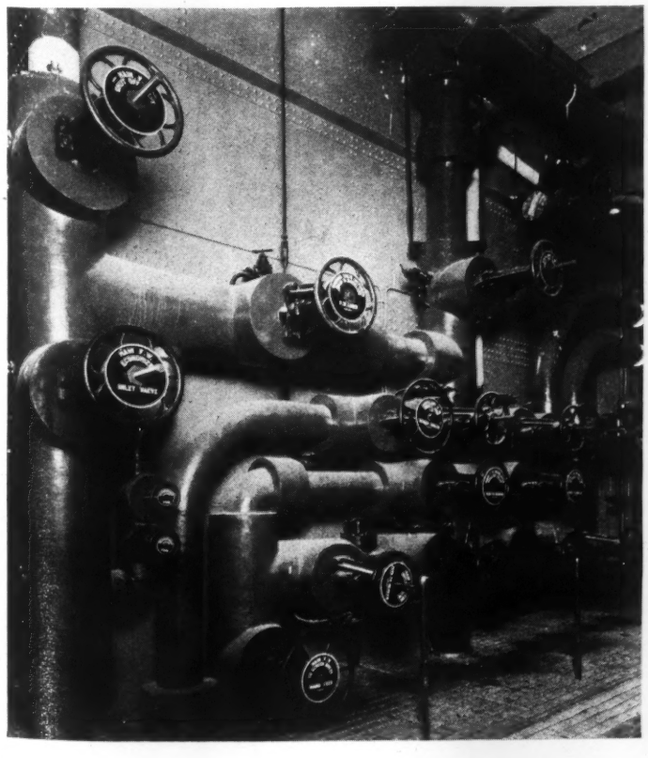
p is the friction loss

k is a constant including $1/2g$ (g = gravitational acceleration)

f is a factor determined by the Reynolds number of the fluid under the particular flow conditions

For viscous flow $f = \frac{64}{R}$

for turbulent flow $f = a + bR^n$†



Boiler feed valve nest, example of complex and expensive piping system that justifies careful analysis to select the best pipe diameter

*Engineer, The Detroit Edison Co., Detroit, Mich.

†Professor Reynolds gave the formula $f = aR^n$ where a is a constant which depends upon dimensions and $n = -0.277$. Tests made in the region of Reynolds numbers considerably higher than those used by Reynolds indicate that $f = a + bR^n$ is a better statement of the relation between the coefficient of friction and Reynolds number.

L is the length of pipe
v is the average velocity of flow
D is the inside diameter of the conduit
y is the density of the fluid
R is the Reynolds number

The following discussion was undertaken as the result of study of several articles on the rational method in which it was observed that the various authors used different coefficients of friction and different Reynolds values in presenting what was supposed to be the same data.

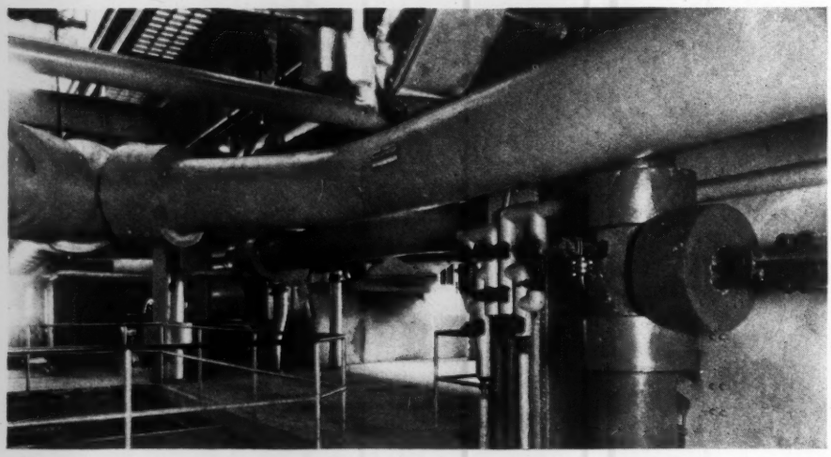
The application of Reynolds numbers to problems in fluid flow had its beginning as far back as 1850 when Stokes, in England, predicted that the coefficient of friction in fluid flow depends on the diameter of line, the velocity of flow, and the density and viscosity of the fluid. This relation was rediscovered in 1883 by Osborne Reynolds. In 1914 Stanton and Pannell published the results of a large number of tests which substantiated Stokes' prediction.

Since publication of the data by Stanton and Pannell the calculation of fluid flow by use of the Reynolds number has met with slowly increasing popularity until it is now quite widely accepted as the only available rational method of solving fluid flow problems. During the last eight or ten years numerous articles have appeared in technical magazines, bulletins, handbooks, and school texts presenting the rational method and data for its use in flow problems. While any one article may be understandable to a reader, the multiplicity of articles tends toward confusion because a number of authors have used different units and arrangements of terms in setting up substitute functions which actually are not Reynolds numbers.

It is the purpose here to reconcile differences between some of these recent articles on fluid flow through:—

(1) A brief discussion of the true Reynolds number;
(2) A discussion of synthetic functions proportional to Reynolds numbers;
(3) A presentation of tables of factors for converting synthetic Reynolds functions into the genuine numbers; and
(4) By indicating where synthetic forms of Reynolds function have been used by recent authors.

The article concludes with the presentation of a method for determining which form of Reynolds function was used by any particular writer, the correct friction loss formula to be used with his coefficients of friction, a reconciliation of some recent articles, and a few words of caution on the use of the "rational method."



Superheated steam piping which was thoroughly checked for pressure loss before 16 in. diameter was decided upon

Reynolds Number Is Dimensionless

In 1883 Professor Reynolds showed by the principles of dimensional homogeneity that the friction factor in all fluid flow problems must be a function of the pipe diameter (or hydraulic radius in non-circular conduits), the velocity of flow, and the density and viscosity of the fluid. His analysis further indicated that if the two sides of the fluid flow equation are to be dimensionally similar, the friction factor would have to be a pure number without dimension. The dimensionless grouping of the factors upon which the frictional coefficient depends is

$$\frac{\textit{diameter x velocity x density.}}{\textit{absolute viscosity}}$$

Further, if this grouping is to result in a pure number, all the units used must belong to one consistent, homogeneous system.

If the English system of units is used all dimensions of length must be in feet or inches, all dimensions of time must be in the same units, *i.e.* seconds, minutes or hours, and all dimensions of weight must be in the same terms, *i.e.*, pounds, ounces, poundals, etc. If feet, lb, and seconds are the units chosen, a typical Reynolds grouping is

$$R = \frac{\text{diam. x velocity x density}}{\text{abs. viscosity}} = \frac{ft \times \frac{ft}{sec} \times \frac{lb}{ft^3}}{\frac{lb}{ft\ sec}} = \text{pure number}$$

If the metric system is used the factors involving length must all be in centimeters or meters, time factors must all be in the same units, and the units of weight must all be the same. If centimeters, grams, and seconds are used, the Reynolds grouping is

$$R = \frac{\text{diam. x velocity x density}}{\text{abs. viscosity}} = \frac{cm \times \frac{cm}{sec} \times \frac{grams}{cm^3}}{\frac{grams}{cm\ sec}} = \text{pure number}$$

Any other system of units can be used, provided that all expressions of length are consistent, all expressions of time are consistent and all expressions of mass are consistent. For various reasons as explained below it is sometimes convenient to use units in a Reynolds group which are not consistent, especially when working in the English system.

Reynolds "Functions"

In this article any grouping of units which is proportional to the Reynolds number but which consists of units that are not consistent and/or homogeneous will be called a *Reynolds function.*

There are a number of Reynolds functions which are used as a matter of convenience. In the English system the diameter may be expressed in inches, where the consistent unit would be feet. Specific gravity or specific volume may be substituted for density. There is no accepted name for the unit of absolute viscosity in the English system and many viscosity data are available in

terms of the metric centipoise. The desire for convenience has led to a number of forms of the Reynolds function, among which the following may be noted as common ones for use when the absolute viscosity is available.

$$\frac{Dvy}{Z}, \frac{Dv}{ZV}, \frac{DvS}{Z}, \frac{W}{ZD}, \frac{Qy}{ZD}$$

where

D = inside diameter
v = velocity
y = density
Z = absolute viscosity
V = specific volume
S = specific gravity
W = lb per hour
Q = gallons per minute

Other arrangements of terms could be made and will occur to the reader.

The measurement of absolute viscosity is a rather difficult laboratory process and numerous viscosity data have been determined and reported on the basis of measurements made with the Saybolt, Engler, or other viscosimeter which measures kinematic viscosity. Kinematic viscosity is the absolute viscosity divided by the density and in the viscosimeters just referred to is a function of the time required for a specified volume of fluid at a specified temperature to flow through an orifice in the bottom of the instrument. If K be used to represent kinematic viscosity, it is evident, by definition, that $K = Z/y$. It is at once apparent that a group of Reynolds functions based on kinematic viscosity will result from substitution of K for Z/y in the Reynolds functions already discussed.

Thus
$$\frac{Dvy}{Z} = C_1 \frac{Dv}{K}$$
$$\frac{Dv}{ZV} = C_2 \frac{Dv}{K}$$
$$\frac{DvS}{Z} = C_3 \frac{Dv}{K}$$
$$\frac{Qy}{ZD} = C_4 \frac{Q}{DK}$$

From the fact that so many different arrangements of terms and units of measurement may be used in determining the same factor f for use in the fluid flow formula it follows that all of these different functions must bear certain definite relations to each other. In order to establish these relationships, conversion factors for units used in the Reynolds function are present here.

Converting Functions to Reynolds Numbers

The factors which appear in the Reynolds function are mass, length, time, and viscosity, which is a function of the other three. The following conversion factors apply:

MASS

$$1 \text{ lb mass} = 453.51 \text{ grams} = \frac{1 \text{ lb force}}{32.174 \text{ ft per sec}^2}$$

1 slug = 32.174 lb mass
1 lb force = 32.174 poundals = (1 lb mass) (32.174 ft per sec^2)
1 kilogram = 1000 grams = 2.205 lb mass
1 dyne = (1 gram mass) (1 cm per sec^2)

$$= \frac{1}{980.665} \text{ gram force}$$

LENGTH

1 foot = 30.48 cm
1 cm = 0.03281 ft
1 sq ft = 929.04 sq cm
1 sq cm = 0.001076 sq ft
1 cu ft = 28,316.8 cu cm
1 cu cm = 0.00003531 cu ft

TIME

The unit of time which is used almost universally is the second.

VISCOSITY

$$1 \text{ poise} = 100 \text{ centipoises} = \frac{1 \text{ dyne sec}}{\text{sq cm}} = \frac{1}{98.07} \frac{\text{kg force sec}}{\text{sq m}}$$
$$= \frac{1 \text{ gram mass}}{\text{cm sec}} = 0.0672 \frac{\text{lb mass}}{\text{ft sec}}$$
$$= 0.0672 \frac{\text{poundal sec}}{\text{sq ft}}$$
$$= 0.00209 \frac{\text{lb force sec}}{\text{sq ft}}$$

The unit of kinematic viscosity has no name in either the metric or English system but is measured as follows:

$$\text{kinematic viscosity} = \frac{\text{absolute viscosity}}{\text{density}} = \frac{\text{poises} \times \text{cu cm}}{\text{grams}} = \text{sq cm per sec}$$

$$100 \times \text{kinematic viscosity} = \frac{\text{centipoises} \times \text{cu cm}}{\text{grams}} = 100 \times \text{sq cm per sec}$$

$$\text{kinematic viscosity} = \frac{\text{lb mass} \times \text{cu ft}}{\text{ft sec} \times \text{lb}} = \text{sq ft per sec}$$

1 sq cm per sec = 0.001076 sq ft per sec
1 sq ft per sec = 929.04 sq cm per sec

Since the centipoise is $\frac{1}{100}$ of a poise,

1 sq ft per sec = 92,904 times the kinematic viscosity based on centipoises.

These conversion factors permit the development of coefficients for converting any of the Reynolds functions to the real Reynolds number.

The Reynolds functions indicated in Table 1 multiplied by the coefficients given in the body of the table will equal the real Reynolds number.

Table 1—Factors for Converting Reynolds Functions to Reynolds Numbers

Reynolds function involving absolute viscosity	$\frac{Dvy}{Z}$	$\frac{dvy}{Z}$	$\frac{dv}{VZ}$	$\frac{dvS}{Z}$	$\frac{QS}{dZ}$	$\frac{Qy}{dZ}$	$\frac{W}{dZ}$
	MULTIPLYING FACTORS						
Absolute viscosity in centipoises	1488	124	124	7742	3162	50.7	6.32
Absolute viscosity in lb mass/ft sec	1	0.0833	0.0833	5.203	2.125	0.0341	0.00425

Reynolds function involving kinematic viscosity	$\frac{Dv}{K}$	$\frac{dv}{K}$	$\frac{Q}{Kd}$
	MULTIPLYING FACTORS		
Kinematic viscosity in 100 sq cm per sec	92,904	7742	3162
Kinematic viscosity in sq ft per sec	1	0.0833	0.0340

D = inside diameter in feet; d = inside diameter in inches; v = velocity in feet per second; y = density in lb per cu ft; V = specific volume in cu ft per lb; Z = absolute viscosity; K = kinematic viscosity; S = specific gravity; Q = flow in U.S. gallons per minute; W = flow in lb per hr.

Identifying Reynolds Functions

In any article on the application of Reynolds functions to fluid flow problems in which the author presents a plot of friction factors against Reynolds functions it

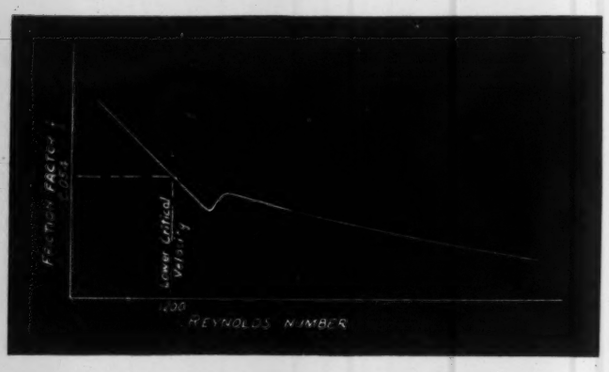


Fig. 1—The Reynolds number at the lower critical velocity is well established at about 1200, as shown. Any other value indicates some function proportional to, but not equal to, the Reynolds number

is possible to identify the author's arrangement of factors and units used in the Reynolds function by noting the value of the function at the lower critical velocity, and referring to the tables given below. The Reynolds number at the lower critical velocity is well established at about 1200. Any other value indicates some function proportional to, but not equal to, the Reynolds number. This condition is indicated in Fig. 1.

Identifying the Proper Friction Loss Formula

The value of the friction factor f at the lower critical velocity is useful in determining the correct friction loss formula to be used with any particular Reynolds plot.

Some plots of f against the Reynolds function show much larger f values than other plots. At the lower critical velocity (Reynolds number = 1200) the value of f should be either 0.054 or 0.0135. It will be noted that the first value is just four times the second one, and the reason for the difference is that the friction loss formula given in the third paragraph of this article actually is developed from the hydraulic radius instead of diameter as shown. For circular sections, the hydraulic radius is $D/4$ and some authors include the 4 in the constant k while others combine it with the value of f. It is imperative, therefore, that one make sure of the basis of friction loss formula he is using before accepting the f values shown on a particular Reynolds plot; otherwise the answer may be either four times too large or four times too small. Seven formulas are given below for each of the two friction factors at the lower critical velocity. The different formulas are presented for the convenient use of whatever data are available in any particular problem; the differences in these data will be evident from inspection of the formulas.

Recent Articles Compared

The "rational method" of handling fluid flow problems has been developed herein to a point where it is now possible to analyze any particular presentation of the subject and to know just what the author was doing. Such analyses have been made of several recent articles and are reported as follows.

Popular acceptance of the rational method followed the publication of an article by Wilson, McAdams, and Seltzer[1]. Their work involved a hybrid Reynolds function using diameter in inches, velocity in feet per second, viscosity in centipoises, and specific gravity. According to Table 2 this combination would have a value of 0.155 at the lower critical velocity. A check of the Reynolds plot which they presented shows this same value. Their friction factor at this point is about 0.013 and the formula they used is $p = \frac{0.323\, fLSv^2}{d}$ which checks with the data given in Table 4.

In the "Piping Handbook," Walker and Crocker have followed the system used by Wilson, McAdams, and Seltzer. Their Reynolds plot, however, has abscissa scales for five different Reynolds functions, all of which are correct. The friction factors should be used with the left column of formulas in Table 4.

Emory Kemler has studied the results of some 10,000 to 12,000 tests in the light of the Reynolds number. This study was reported in the *A. S. M. E. Transactions* for 1933 (HYD-55-2). All of this work was done on the basis of consistent English units having a Reynolds number of 1200 and friction factor 0.054 at the lower critical velocity. Subsequent articles by Kemler in Heating, Piping and Air Conditioning beginning in October, 1933, also are based on consistent English units. Discussions of Kemler's paper by Rhodes and others, also published in the *A. S. M. E. Transactions* HYD-55-2 point out the possibilities of confusion which exist among the many articles on the use of Reynolds numbers.

In *Mechanical Engineering,* August, 1933, R. J. S. Pigott presented an attempt to correct for the roughness of closed conduits. His data are taken largely from Kemler's work and are, therefore, based on consistent English units.

"Heat-Power Engineering" (Part III) by Barnard, Ellenwood and Hirshfeld contains a good presentation of the rational method based on consistent English units. A recent publication[2] entitled "Engineering Data on Flow of Fluids in Pipes and Heat Transmission" presents an abbreviated version of the discussion given in "Heat-Power Engineering." It is, of course, based on consistent English units with Reynolds number 1200 and friction factor 0.054 at the lower critical velocity.

In Heating, Piping and Air Conditioning, January, 1935, in "Design of Modern Industrial Piping Systems," by F. L. Snyder, a group of nomographs for solving fluid flow problems was presented. They are based upon a Reynolds function m/ZD in which m is the weight of flow in thousands of pounds per hour, Z is the absolute viscosity in centipoises and D is the diameter in inches. A mis-statement appears in the last paragraph of the first page; *i.e.*, $f = m/ZD$. The factor f is a function of m/ZD which actually decreases in value as m/ZD increases; it is *not equal* to m/ZD. In a number of cases tried by the present writer these nomographs give values about 40 per cent greater than

[1]See *Journal of Industrial and Engineering Chemistry*, February, 1922.
[2]Published by Crane Co., 1935.

those calculated for clean steel pipe from the pressure drop formulas using friction factors corresponding to the Reynolds number for the particular flow conditions.

Forrest M. Towl has written a book called "*f*, The Pipe Line Flow Factor" in which he disputes the idea that the term y/Z in the Reynolds number has any bearing on the value of f. He contends that f varies only with the product of velocity and diameter, and proceeds to develop his analysis on the basis of the steady flow of water through a circular pipe one foot in diameter. At the end, however, he says that for fluids other than water, a correction must be made for the change in kinematic viscosity.

Using the Rational Method of Calculation

The wide range of possible presentations of the rational method has been indicated in this article. When properly interpreted and applied any of the presentations discussed herein will produce the same answer for pressure drop. It is advisable, however, to select the method proposed by one author and abide by it. Data from other sources should not be used unless their units are consistent with the units of the presentation which is being followed.

The rational method is, perhaps, the most satisfactory way of calculating pressure drops in fluid flow problems. Its superiority depends upon careful use, however, and the danger of making serious errors is great if one scrambles the data from different sources without checking the units.

Table 2—Values of Reynolds Functions Involving Absolute Viscosity at Lower Critical Velocity

Value of Reynolds Function	Terms				Arrangement
	D or d	v	y	Z	
1200	ft	ft per sec	lb per cu ft	lb mass per ft sec	$\frac{Dvy}{Z}$
1200	cm	cm per sec	grams per cu cm	grams per cm sec	$\frac{dvy}{Z}$
1200	Any homogeneous system of units				$\frac{Dvy}{Z}$
0.806	ft	ft per sec	lb per cu ft	centipoises	$\frac{Dvy}{Z}$
9.68	inches	ft per sec	lb per cu ft	centipoises	$\frac{dvy}{Z}$
9.68	inches	ft per sec	$\frac{1}{\text{cu ft per lb}} = \frac{1}{V}$	centipoises	$\frac{dv}{ZV}$
0.155	inches	ft per sec	sp gravity $= S$	centipoises	$\frac{dvS}{Z}$
0.379	inches	U.S. gpm $= Q$	sp gravity $= S$	centipoises	$\frac{QS}{Zd}$
23.65	inches	U.S. gpm $= Q$	lb per cu ft	centipoises	$\frac{Qy}{Zd}$
189.8	inches	lb per hour $= W$		centipoises	$\frac{W}{Zd}$
14,400	inches	ft per sec	lb per cu ft	lb mass per ft sec	$\frac{dvy}{Z}$
14,400	inches	ft per sec	$\frac{1}{\text{cu ft per lb}} = \frac{1}{V}$	lb mass per ft sec	$\frac{dv}{ZV}$
230.5	inches	ft per sec	sp gravity $= S$	lb mass per ft sec	$\frac{dvS}{Z}$
564	inches	U.S. gpm $= Q$	sp gravity $= S$	lb mass per ft sec	$\frac{QS}{Zd}$
35,200	inches	U.S. gpm $= Q$	lb per cu ft	lb mass per ft sec	$\frac{Qy}{Zd}$
282,000	inches	lb per hr $= W$		lb mass per ft sec	$\frac{W}{Zd}$

Table 3—Value of Reynolds Functions Involving Kinematic Viscosity at Lower Critical Velocity

Value of Reynolds Function	Terms				Arrangement
	D or d	v	Q	K	
1200	ft	ft per sec		sq ft per sec	$\frac{Dv}{K}$
14,400	inches	ft per sec		sq ft per sec	$\frac{dv}{K}$
0.0129	ft	ft per sec		100 sq cm per sec	$\frac{Dv}{K}$
0.1550	inches	ft per sec		100 sq cm per sec	$\frac{dv}{K}$
35,200	inches		U.S. gpm	sq ft per sec	$\frac{Q}{dK}$
0.379	inches		U.S. gpm	100 sq cm per sec	$\frac{Q}{dK}$

Table 4—Friction Loss Formulas

Value of f at Lower Critical Velocity →	0.0135	0.054
Pressure loss formulas	$p = \frac{0.005176\ fLv^2y}{d}$	$p = \frac{0.001294\ fLv^2y}{d}$
p = pressure loss, lb per sq in	$= \frac{0.005176\ fLv^2}{Vd}$	$= \frac{0.001294\ fLv^2}{Vd}$
f = friction factor from Reynolds plot	$= \frac{0.323\ fLsv^2}{d}$	$= \frac{0.08075\ fLSv^2}{d}$
L = length of pipe, ft	$= \frac{0.0538\ fLSQ^2}{d^5}$	$= \frac{0.01345\ fLSQ^2}{d^5}$
d = inside diameter of pipe, inches	$= \frac{0.0008638\ fLyQ^2}{d^5}$	$= \frac{0.0002159\ fLyQ^2}{d^5}$
v = velocity in ft per sec	$= \frac{0.00001343\ fLVW^2}{d^5}$	$= \frac{0.00000336\ fLVW^2}{d^5}$
Q = flow in U.S. gpm	$= \frac{0.00001343\ fLW^2}{yd^5}$	$= \frac{0.00000336\ fLW^2}{yd^5}$
W = flow in lb per hr		
y = density in lb per cu ft		
V = sp. vol., cu ft per lb		

Air Conditioning Modernizes Office Building

IN the spring of 1933 the Oklahoma Gas and Electric Co. installed an air conditioning system in the "Electrical Bungalow," which is located in the basement of the company's main office building in Oklahoma City. It created so much public interest and proved to be so comfortable that it was decided to plan for the ultimate air conditioning of the entire building. First unit of this plan, consisting of the first (main) floor, the fifth floor and part of the second floor, was completed during the following spring. This installation and its operation is interesting in several respects, and employs a method of compensated effective temperature control.

Two 28 Ton Ammonia Compressors

Because it was impossible to find room in the building for vertical duct risers, and as it was also found impracticable to run "Freon" lines to the different units serving the building, an indirect system was used. The refrigeration equipment is located in the machinery room in the sub-basement and consists of two 28 ton reciprocating ammonia compressors, two horizontal shell and tube condensers and a horizontal receiver. The refrigerant is expanded in a horizontal shell and tube chiller, through which the secondary refrigerant (water) is circulated by two 105 gpm turbine pumps. The chiller has a capacity of 125 tons, adequate to supply the future demands of the entire building.

The chilled water flows from the chiller to two 1100 gallon storage tanks, used during the summer cycle only, their purpose being to eliminate too frequent cycling of the compressors and to insure continuous flow of cold water to the units through possible short shut-downs.

The compressors are controlled by two immersion thermostats placed in the chilled water line, one of which is set 5 F above the other. As the water temperature rises above the setting of the first thermostat, one compressor is brought into operation. Should the water temperature continue to rise and reach the setting of the second thermostat, the other compressor is started. The compressors will cut out in reverse order as the water temperature is lowered. Limits of the water temperatures are 44 F high and 35 F low.

Condensing water is cooled by means of a 300 gpm atmospheric spray type cooling tower on the roof of the building, the pipe lines to the tower being designed for the ultimate capacity of the plant. The city water is so hard that it was found to be profitable to run all make-up water for the cooling system through a water softener before entering the system.

The original heating system was a two pipe steam job with cast iron radiation. Installation of the present system eliminated the radiators and the space is conditioned in winter by circulation of hot water (provided by an instantaneous heater supplied with steam from the present boiler) through the same pipes and coils used during the summer cycle. Water temperature varies between 112 and 100 F.

Conditioning the Main Floor

The first floor consists, principally, of one main room and an elevator lobby. The former is highly decorated and consequently it would be impossible to install ducts to distribute conditioned air. It was, therefore, necessary to install four separate units:

A 10 ton unit mounted on top of the vestibule to the main entrance of the floor at the northeast corner of the building, concealed by extending the vestibule walls higher.

A 14 ton unit suspended over the driveway at the west end of the building, connected with duct work to grilles in the west wall.

The south part of the space is conditioned by two 5 ton units, one enclosed over the ladies' rest room, and the other suspended above the hallway leading to the only totally enclosed office on the floor.

The air is distributed from these units through high velocity diffuser type grilles, and the returns are taken from the floor below the units. Fresh air is supplied to the space through the two large units on the east and west walls, the units on the south handling recirculated air only. The longest blow used on this floor is 85 ft.

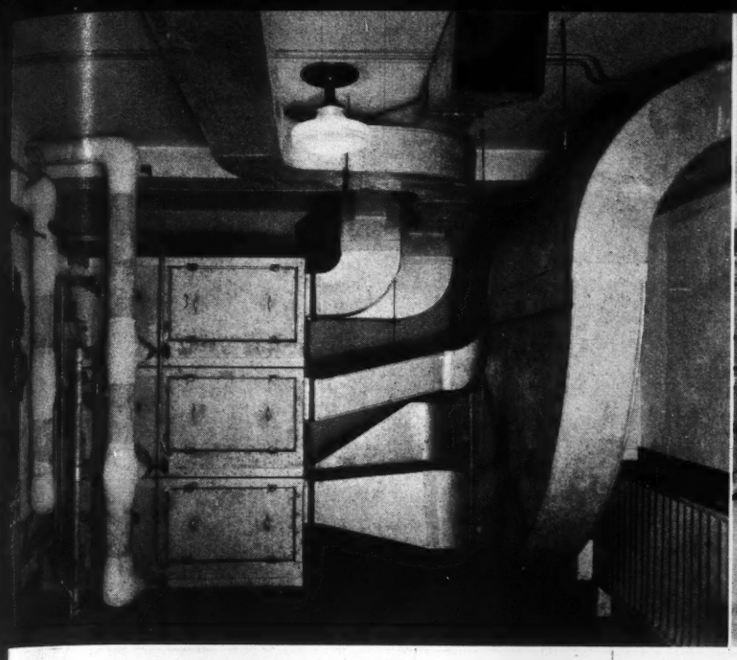
The first floor is divided into two main control zones divided by an imaginary line running from the southwest to the northeast corner.

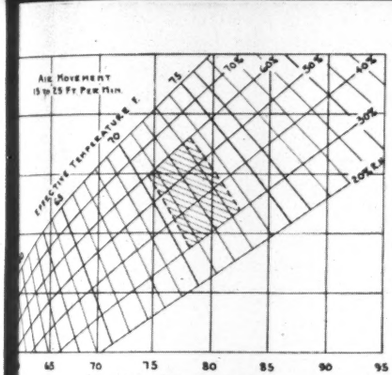
Three Zones for Fifth Floor

The fifth floor is supplied with conditioned air from a centrally placed fan room, with the upper part of the corridor used for main supply ducts and the main part of the corridor as a return. The return from individual offices is emptied into the corridor through dampered grilles in the doors. The floor is divided into three zones (north, east and south) and each zone is supplied from a separate unit through a separate duct system. All units are in the fan room and stacked on top of each other to conserve space and simplify piping. Each consists of a set of motor driven blowers, finned tube coils through which cold water is circulated in summer and hot water in winter, filters, bypass and face dampers, spray humidifiers for winter, and eliminator plates.

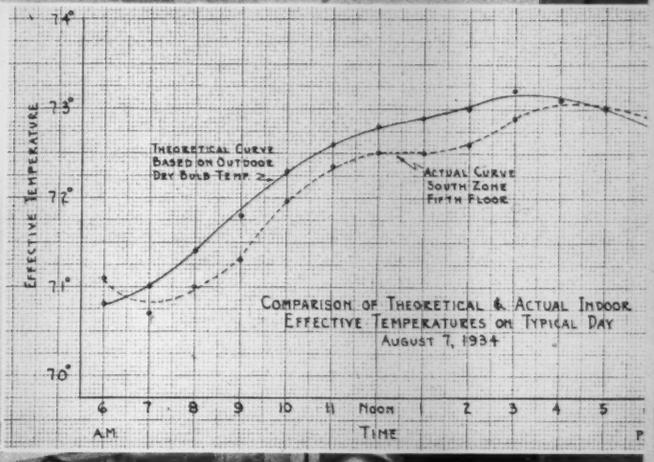
All branch ducts entering offices are disguised as beams and furred in with lath and plaster. The ceiling

***Top, left to right*—Fifth floor fan room showing the three units for the three zones stacked on top of each other to save space and simplify the piping . . . . . Main floor with 10 ton unit concealed over entrance . . . . . *Center, left to right*—Comfort chart showing conditions maintained in summer . . . . . Main office building of Oklahoma Gas and Electric Co. . . . . Comparison of theoretical and actual indoor effective temperatures maintained by the control system . . . . . *Bottom, left to right*—Chiller, pumps, storage tanks and other equipment in sub-basement . . . . . Ammonia compressors and the main control board**

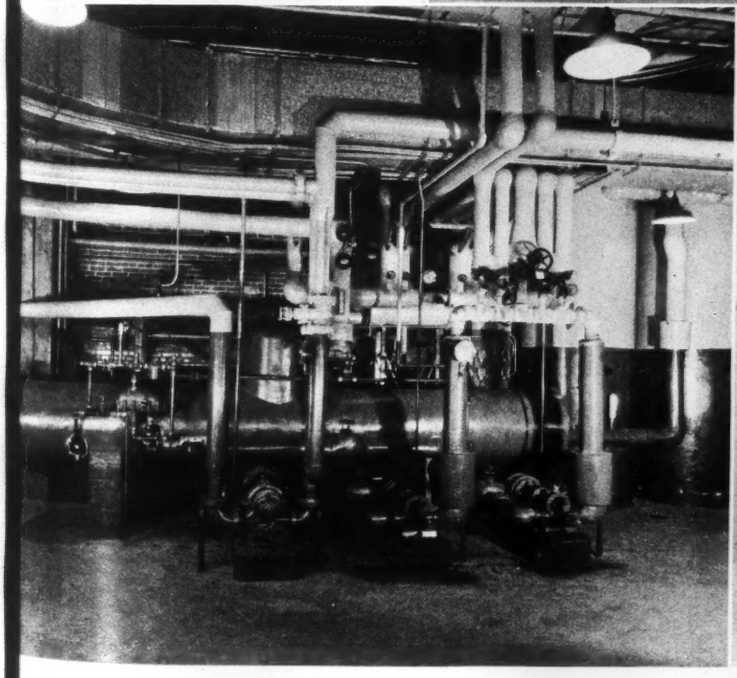


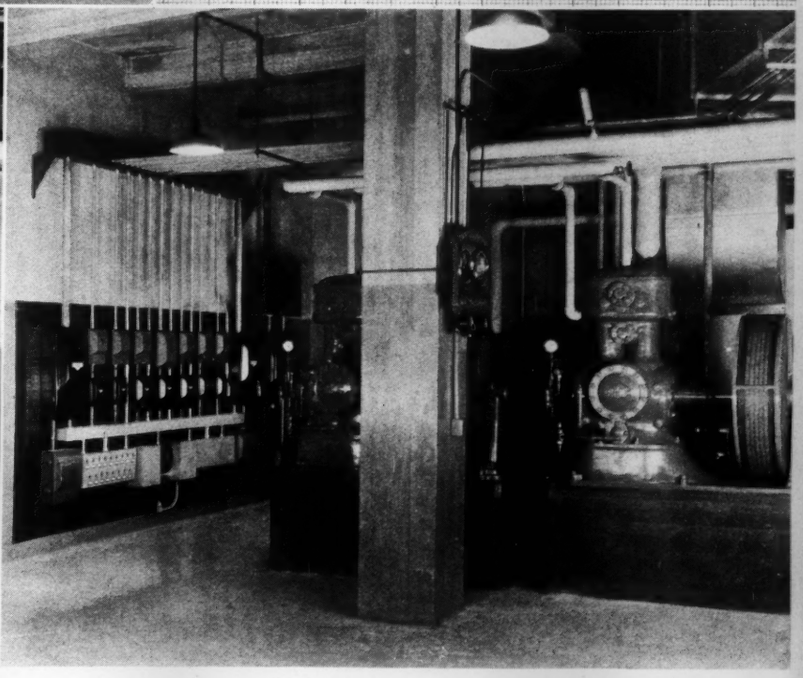


Summer Comfort Zone Maintained by Air Conditioning System in O.G.&E. Co. Main Office Bldg.



Comparison of Theoretical & Actual Indoor Effective Temperatures on Typical Day
August 7, 1934





..... *By* S. L. Rolland*

Realizing the advantages of air conditioning, the Oklahoma Gas and Electric Co. made plans ultimately to condition its entire main office building; first unit of the plan is described here

..... **Among the interesting features is the method of effective temperature control which compensates for changes in the outdoor weather** .....**How air conditioning equipment may be adapted to an existing building is also told**

*Design Engineer, Oklahoma Gas and Electric Co., Oklahoma City, Okla.

No definite data on the effect of air conditioning on the efficiency of employees are available, except for statements from the employees themselves.

It was felt that possibly employees who had been working in an air conditioned room all day would suffer more from the heat when they left in the afternoon, than if they had not been subject to air conditioning. However, statements made by all employees are that, due to having been comfortable all day long, they are not fagged out when leaving the office in the evening and are in a better position to stand the heat the remainder of the day, than they were before the office was air conditioned.

It is felt that the efficiency of employees working on the air conditioned floors has increased materially; particularly, employees who deal with the public constantly are in a much better frame of mind to do so during the hot weather. However, it has not been attempted to determine scientifically how much the efficiency of the personnel on the air conditioned floors has increased.

Absences due to illness have decreased on the air conditioned floors, particularly so in the winter time; however, in this case also it is impossible to say just how much—S. L. Rolland.

in the corridor was lowered to conceal the main supply ducts. All units are provided with a common return and common fresh air supply.

Fresh air is provided through a louvered opening in the outside wall of the fan room and is mixed with the return air before entering the units, and the fan room also has an opening to exhaust return air. Both openings are sized so that quantities of fresh air, up to the full capacity of the ventilating plant, may be brought in and circulated through the floor and exhausted.

It was believed, and later verified by actual operation, that the outside air will be of such a quality for considerble periods of time that it may be used without either cooling or heating. The limits for this interval were established by experience, and controls set either to cut off the heating or the refrigeration as soon as either the upper or lower limit was reached, open the fresh air and exhaust dampers and close the recirculating damper.

Control Balances Indoor With Outdoor Conditions

It was realized that the control system plays a very important part in an air conditioning installation, both in comfort and economy of operation. A compensated effective temperature control type of system is used throughout, as it was felt that this system takes into consideration the proper relation between outside and inside temperatures and relative humidity, presuming a fixed air movement in the room. This is accomplished by the use of an outdoor temperature compensator, an inside relative humidity compensator, and an inside thermostat, the resultant of which, in turn, modulates face and bypass dampers in the units. Each of the five zones in the building has a complete control system.

No attempt is made to control the relative humidity at a fixed point in the summer, as long as it remains below a predetermined maximum value; thus, advantage may be taken of the many hot, dry days when the humidity is so low that only sensible cooling is required, and even then quite often only to a point which produces a predetermined effective temperature at a higher dry bulb temperature, thereby promoting maximum operating economy.

During cool, damp weather the relative humidity is permitted to rise as high as 60 per cent, but the dry bulb temperature is automatically controlled at a relatively lower point, thereby maintaining comfort conditions with a minimum removal of latent heat in order again to insure economic operation.

The accompanying chart shows the zone within which it was found necessary to operate to insure comfort. The limits of this comfort zone were established by experience, and it was found that any divergence beyond them would immediately result in complaints from the occupants. The schedule finally adopted for summer operation is:

Outdoor Temperature, F	Indoor Effective Temperature, F
75	70.5
80	71.0
85	71.5
90	72.0
95	72.5
100	73.0
105	73.5

Indoor dry bulb temperatures are limited to 75 F low and 82 F high, and the indoor relative humidities to 30 per cent low and 60 per cent high.

The graph illustrates the accuracy to which the inside effective temperatures were held on one typical day taken at random from the charts for one of the zones. The solid line represents the theoretically correct inside effective temperatures and the broken line the actual inside effective temperatures.

Should the relative humidity ever exceed 60 per cent on the inside without the necessity to remove sensible heat, an auxiliary switch in the relative humidity compensator permits a reduced quantity of air to pass through the coils, removing a maximum amount of moisture with a minimum of sensible cooling.

In winter the dry bulb temperature is controlled by modulating face and bypass dampers in front of the coils, as called for by the thermostats in the respective zones. A fixed temperature is maintained during the winter, and the relative humidity is also maintained at a fixed point during the winter cycle by means of spray nozzles in the units controlled by humidity controllers in the respective zones.

Recording charts showing inside relative humidity and inside dry bulb temperature are placed at representative points in each zone and a continuous record is kept during the year. A recording instrument on the roof of the building keeps continuous records of outside dry bulb temperature and relative humidity. We do not consider this advisable for the average installation, but felt the importance of keeping these data, as well as a careful record of complaints, comments and all circumstances which might influence such complaints.

The Tom Dolan Heating Co. was the contractor.

Design Conditions:	**Summer**		**Winter**	
	Outside	Inside	Outside	Inside
Dry Bulb Temperature, F	95	80	5	70
Wet Bulb Temperature, F	77	67		
Relative Humidity, Per cent	44	50		
Area, sq ft	18,895		20,860	
Content, cu ft	254,700		279,200	
(Elevator lobbies included in winter, omitted in summer)				
Total Load—First floor	277,110		326,500	
Second floor	36,440		50,400	
Fifth floor	248,525		250,000	
	562,075 Btu's = 46.8 Tons		626,900 Btu's	

(Occupancy of 120 people and 26.6 kw lighting load neglected)

Method of Steam Jacketing Piping for Handling Heavy Oil, Tar

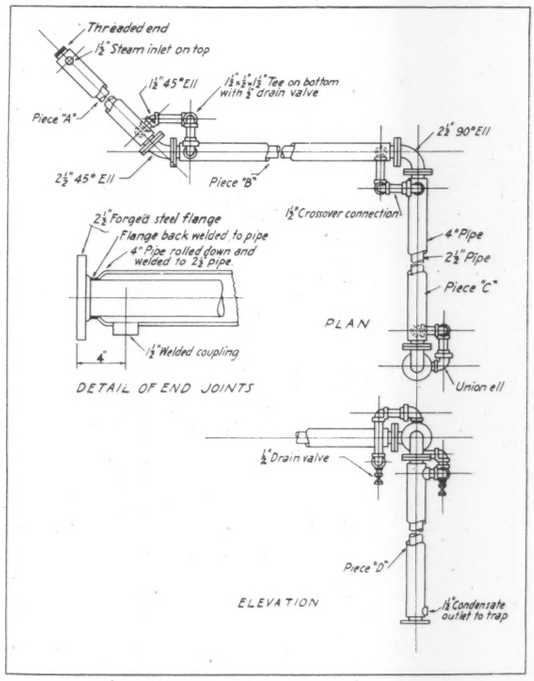
By G. W. Hauck*

WHEN heavy or viscous fluids are to be transported through piping installed in unprotected places or affected by low temperatures, provision must be made for the application of heat to keep the material sufficiently fluid to permit pumping. The sketches show how this problem was handled in connection with a piping system for conveying heavy road oils and tar.

This particular line is installed outside a building and is used for loading purposes. The 2½ in. piping conducting the fluid is jacketed by means of a 4 in. pipe envelope, the annular space between the 2½ and 4 in. pipe providing a steam jacket. Steam is admitted at one terminal end through a 1½ in. welded connection, and steam cross-over connections are provided between the various sections of the piping system, terminating in a 1½ in. condensate drain connection at the end of the pipe line.

In the steam connections, the outlet is taken from the bottom at each section and carried over to the top of the next section. Each of the 1½ in. cross-over steam connections has a 1½ x ½ x 1½ in. tee at the bottom, or low point, and ½ in. drain valves are installed to permit complete drainage of all condensate when closing down, and particularly to prevent water hammer when starting up, or freezing during a shut-down in cold weather.

*Engineer, Crane Co., Cincinnati, Ohio.



Steam-jacketed piping for heavy road oils

For comparatively short lines, it is satisfactory to provide the cross-over connections for a continuous flow from steam inlet at one end to condensate outlet at the other end; in this arrangement, the condensate is carried through from one section to another because of the pressure of the steam. However, for long lines it would be advisable to install a separate condensate line paralleling the jacketed line to which each jacketed section could be individually connected.

For occasional cleaning and inspection, rapid and easy removal and re-assembly of the piping sections was desirable; hence, flanged fittings were used at all turns in the 2½ in. line. The union elbows in the 1½ in. cross-over connections likewise make for easy separation of the sections.

A detail of the construction of the end joints is shown. The 4 in. pipe was rolled down and welded to the 2½ in. immediately adjacent to the flanges. The welding was continued beyond the point of contact between the 4 and 2½ in. pipe to provide back welding of the forged steel flanges used on the 2½ in. inner pipe. All 1½ in. connections for cross-overs were made by welding in 1½ in. extra heavy couplings.

This line has been in service for over a year, and has proved entirely satisfactory for the purpose.

Metallic Pipe Insulation

TESTS on metallic heat insulation as pipe covering described by J. T. Nichols* indicate a coefficient of 0.26 Btu per hr per F per sq ft per in., as shown in the table. The testing method consisted of heating a length of insulated pipe with three separate sectional electric heaters provided with control rheostats for equalizing the temperatures at various points on the pipe surface. After equilibrium was reached the electrical input to the center section, the pipe surface temperature, and insulation surface temperature were read, from which the heat conductivity of the insulation was determined.

In the tests described a 10 in. pipe 5 ft long was used, the actual test section in the center being 2 ft in length. Thus the guarded zone principle was used, input to the three sections being balanced and equalized, but only the data for the 2 ft center section used to calculate conductivity of the covering.

Tests on Metallic Insulation for 10 In. Pipe

Insulation	Pipe Temperature F	Temperatures at Outer Surface of Insulation, F	Input to 2 Ft Length, Watts	Coeff, Btu per Hr per F per Sq Ft per In.
4 sheet steel ⅜-in. spaces	485	147	167	0.26
4 sheet steel ⅜-in. spaces	475	161	172	0.26

*Of American Sheet and Tin Plate Co., Pittsburgh, Pa., in a paper contributed for presentation at a meeting of the metropolitan section of *The American Society of Mechanical Engineers*, New York, N. Y.

A Problem in

Trouble Shooting

By **William Goodman***

Heating plant operating difficulties frequently arise from obscure, hard-to-locate causes, demand skill and ingenuity of the "trouble-shooter". Such a trouble job occurred in a theater, where the boiler lost water under certain operating conditions . . . . . Before turning to the answer in the back section, the reader may wish to test his "trouble-shooting" skill.

NEARLY every heating man has had forcibly borne home to him at one time or another the operating troubles which can arise from obscure and often insignificant causes. Such a difficulty occurred in a motion picture theater. From the first day the heating plant was started, the boiler lost water under certain operating conditions. Although a number of remedies were tried, the condition had never been completely cured.

The System

The auditorium is heated by means of furnaces. A 50,000 cfm supply fan withdraws air from a plenum chamber, Fig. 1, which extends under the entire main floor of the auditorium. Floor mushrooms allow return air to flow from the auditorium into the plenum chamber and thence back to the supply fan. This fan can take all its air from outdoors, but in actual operation only a small quantity of outdoor air is used.

The air is heated by furnaces on the discharge side of the fan, after which it is discharged into two sheet metal ducts in the return air plenum chamber, which are of course, sealed off from the chamber. The ducts deliver the air to the auditorium through mushrooms in the floor directly above. The exhaust mushrooms are of course at some distance from those for supplying air, and are located along the rear and side walls of the auditorium. Since practically the entire air supply is recirculated through the exhaust mushrooms and pulled back to the supply fan through the plenum chamber, there is a noticeable air movement throughout the chamber.

Steam radiators, Fig. 2, around the outer walls of the auditorium, and in the lobby, lounges and rest rooms are supplied by a coal-fired, low pressure steel boiler in the basement under the stage, and the supply and return mains for the auditorium and lobby radiators are in the plenum chamber.

The major part of the radiator heating system is two pipe gravity with a dry return. All of the return mains are under full steam pressure. Connections to three steam mains are taken from the boiler header to supply radiators in the following locations:

1. One steam supply main for the radiators in the auditorium, lobby, lounges, etc. This is a two pipe system.
2. One steam supply main for radiators in the dressing room section at one end of the stage. This is a one pipe system.
3. One steam supply main for the wall radiation on the rear wall of the stage. This is a two pipe system.

The returns from each of these three sections are separately connected into the boiler return header below the water line. They are therefore sealed off from each other and there is no possibility of steam from one return backing up into the other.

The Trouble

Arriving at the theater one cold afternoon during a matinee, we had a demonstration staged by opening the draft dampers and firing sufficient coal to build up the pressure. Sure enough, as the pressure rose, the water level in the gauge glass fell. At about 6 lb pressure, the water completely disappeared from the bottom of the gauge glass. The fire was checked and the pressure allowed to drop. As the pressure fell, the water slowly reappeared in the gauge glass until at about ½ lb pressure, it again stood at normal.

The First Analysis

While the boiler pressure was rising, the water level in the gauge glass first dropped quickly, then very slowly, which seemed to indicate that the water at first backed into the return mains until it was stopped by the check valves in the return branch from each radiator. After that, the steam condensing in the radiators was unable to flow out because boiler pressure against the water in the return mains kept the flaps of the check valves closed. As a result, sufficient boiler water accumulated in the radiators so that by the time the boiler pressure reached about 6 lb the water line in the boiler gauge glass completely disappeared. If this analysis were correct, the lower radiators should be water-logged. There would, of course, be no water in those on the higher levels, since the water could drain from them against the boiler pressure.

The Test

To test this reasoning the fireman was instructed to fire the boiler again and carry as much pressure as possible without the water line completely leaving the gauge glass. At about 5 lb pressure, the water level stood about ½ in. above the bottom of the gauge glass. Leaving the boiler in the care of the fireman, we started out to see if the lower radiators were waterlogged. The first tried was a radiator on the rear wall of the stage with its bottom about 6 in. above the floor. We backed the radiator air vent out a few turns when a hiss of steam warned that here was no radiator with water in it, but one with steam under pressure. This did not look promising; we had made up our minds that the lowest radiators should be water-logged and here was one functioning normally.

Next we tried the radiator in the stage manager's office, also on the stage level, fed by the steam main supplying the dressing rooms above, not the same one which sup-

*Engineer, The Trane Co., La Crosse, Wis.

plies the radiators on the rear stage wall. Upon attempting to remove the air vent, we were again greeted by escaping steam. Both of these radiators are less than 9 ft above the boiler line. With 6 lb pressure in the boiler, the water could back up to a height of 14 ft above the boiler water line if there were no pressure in the radiators.

We now turned to the lobby radiators, without much hope. The lobby floor is about 2 ft higher than the stage level. As no water was found in the stage radiators, it seemed hardly possible that water would be found in the lobby radiators. Yet the water must be in the system and it did not seem possible that it could back into the return piping without a good deal of condensed steam being held back in the radiators. Upon backing off the air vent of one of the lobby radiators, a trickle of water appeared.

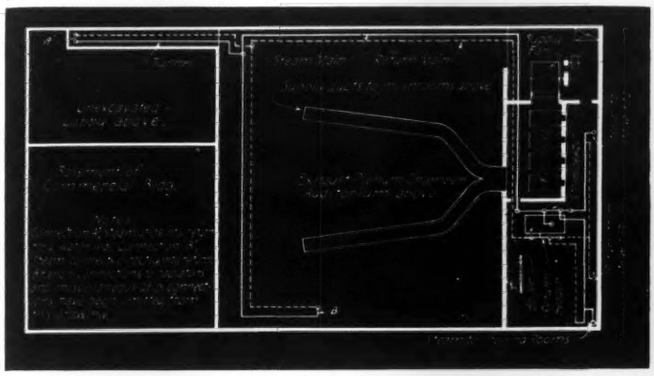


Fig. 1—Plan of stage basement and auditorium plenum chamber

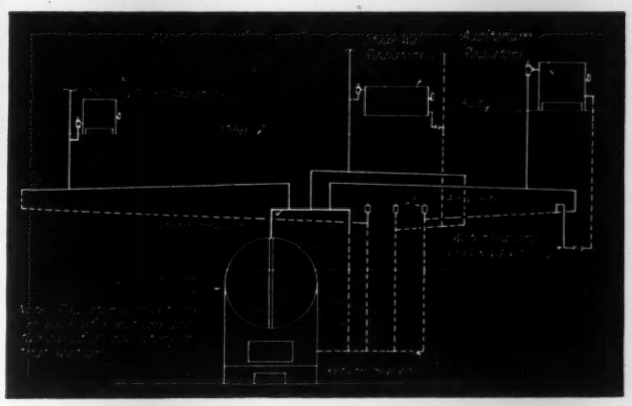


Fig. 2—Diagram of steam mains, returns and radiator connections

This was gratifying but puzzling. How was it possible for the lobby radiators to be flooded and not those on the stage?

There was only one possible answer—that water was backing up only in the one return line which drained the lobby and auditorium radiators, while the remaining two steam mains and their returns functioned normally. Whether or not this surmise was correct could be determined in the boiler room, since there is a large float type air vent at the end of each one of the three return mains, just at the point where they drop below the water line and into the return header. These air vents offered a perfect means of checking the possibility that only the dry return main from the lobby and auditorium radiators was flooded while the remaining two were dry. If the two return lines from the stage and dressing room were not flooded, steam should escape when the air vents were backed out.

Returning to the boiler room we slowly unscrewed the air vent on the return line from the stage wall radiators. Sure enough, steam started to blow and the vent was hastily turned back into place. Unscrewing the vent on the return line from the dressing room yielded the same result, but on trying the air vent on the return line from the lobby and auditorium radiators, water squirted in all directions. It was now evident that water was backing up only in the return main from the lobby and auditorium radiators.

The return piping was carefully scrutinized to determine why the water should back up in the auditorium return main alone and not in the other two. The return connections from the three portions of the heating system were as identical as it was possible to make them. While some of the connections were not in accordance with the best practice, we did not find any which might be suspected of causing trouble. Attention was next turned to the connections at the radiators and there also we found nothing to suspect.

Nothing was left but to crawl into the plenum chamber below the auditorium floor and check all the return mains running through the chamber. After first instructing the fireman to allow the boiler pressure to drop, we entered the plenum chamber.

All of the lobby and auditorium radiators connect into the return main through a water seal with a check valve in the bottom of it, Fig. 2. The end of the steam main connects directly into the return main without any seal. The last 25 ft of the steam main is 1 in. in size and at the very end, after the connection to the last radiator, the steam main is reduced to ½ in. and then connects directly into the return main. The return main then circles back around the walls of the plenum chamber in parallel with the steam main, Fig. 1. The return main continually increases in size as it approaches the boiler room. Aside from the small connection between the end of the steam main and the beginning of the return main, all of the piping is properly installed and the various connections correctly made. The steam main was insulated but the return was not.

While the plenum space is cramped, it is fortunately well ventilated. The brisk air movement throughout the plenum chamber due to the exhaust through the mushrooms above was pleasant and helped to mitigate the unpleasantness due to our cramped positions.

After examining every foot of steam and return piping in the plenum chamber we found nothing out of the ordinary. While the small connection between the steam main and the return main in the plenum chamber is undoubtedly not in accord with the best practice, it did not seem that it in itself could be the cause of the trouble.

[From the information given above, source of the trouble was located and the proper remedies applied. Before reading the answer on page 98, back section, readers may wish to test their own "trouble-shooting" skill.—THE EDITOR.]

Specifications for Radiographic Examination of Steel Castings for Piping Service

By **Herbert R. Isenburger***

THERE are no standards governing the technique to be pursued in the x-ray examination of castings and forgings for high pressure and temperature piping service, the way in which objects and areas examined shall be marked for identification, and the grounds upon which objects shall be accepted or rejected. The technique is left entirely to the judgment of the x-ray inspection group, the marking system is usually peculiar to that group, while the onus of acceptance or rejection is sometimes borne by that group and sometimes is shifted to those for whom the work is being done.

In our practice, the following specifications have proved satisfactory:

1. If a casting, after being radiographed, is accepted by Purchaser, said casting will be returned to Foundry for finishing. Upon receipt of said casting, Foundry will immediately proceed with its fabrication. Upon completion, casting shall be tested with kerosene in the customary way.

2. In the event that Purchaser, after a casting has been radiographed, feels that said casting is defective to such an extent that it should be replaced, Purchaser will notify Foundry to this effect and will submit all pertinent details and radiographs to Foundry for their study and consideration. Foundry will then submit these data to their own metallurgist and/or foundry expert and/or engineer for their criticism.

(a) If Foundry is then also convinced that said casting is defective and should be replaced, Foundry shall then proceed immediately with a new casting which shall be submitted for radiographic examination following the same procedure as with the original as above specified. This procedure shall be repeated, if necessary, until a satisfactory casting acceptable to Purchaser has been produced or until Foundry disagrees with Purchaser's disapproval, in which latter event procedure shall be carried forward as specified hereafter.

(b) If Foundry, after consultation with their own experts, believes said casting is satisfactory for service or may be made satisfactory for service by applying certain remedial measures, they will so advise Purchaser who will either transmit Foundry's comments and suggestions to the x-ray laboratory for consideration or arrange a conference between Foundry's experts and/or the x-ray laboratory's experts and/or Purchaser's representatives. In more precise definition of said "Purchaser's representatives," Purchaser may, at his discretion, elect to have present at said conference a member of his own organization and/or an expert extra to his own organization and also extra to the x-ray laboratory's organization.

If, as a result of such conference, it is mutually agreed that the casting is acceptable, said casting shall be returned to Foundry's shop for fabrication. If it is mutually agreed that said casting may be made acceptable by applying certain remedial measures, said casting shall then be returned to Foundry's shop where the defects shall be corrected as discussed in said conference. After such correction, the casting shall either be fabricated or shall be returned for further radiographic examination at the option of the Purchaser. The Purchaser will be guided in this decision by the nature of the defects and the nature of the remedy. Should said casting be re-x-rayed and adjudged unfit, the matter shall be subjected to re-discussion under the same procedure as above. Should said casting be re-x-rayed and accepted by Purchaser, it will be returned to Foundry's shop for fabrication.

In the event that an agreement cannot be effected, a neutral expert shall be brought in who will act as arbiter. The judgment of said arbiter shall be accepted by both the Foundry and the Purchaser as final. This arbiter shall be an expert x-ray technician thoroughly familiar with the science of radiography and the interpretation of its results and also have some knowledge of foundry practice and metallurgy and shall be familiar with the service requirements for the casting's ultimate use. Said arbiter shall be so chosen that he will be acceptable to both Foundry and Purchaser. Payment for said arbiter's services, should arbitration become necessary, will be discussed at that time.

Should the arbiter adjudge the casting to be defective and unfit for long time continuous service, the Foundry shall immediately proceed to replace the defective casting with a new one which shall be submitted for radiographic examination under the same procedure as before. Should the arbiter adjudge that the casting is quite fit for long-time continuous service, the Purchaser will accept said casting which will be returned to Foundry's shops where it shall be immediately entered into the processes of fabrication. Should the arbiter adjudge that the defects are of a minor nature possible of correction, said casting will be returned to Foundry's shops where such correction shall be executed and the casting be returned for further x-ray inspection, under the procedure above specified.

3. In the event that Purchaser, after radiographic examination, believes that a casting is defective but that the defects are of such a nature that they may be satisfactorily corrected, Purchaser will notify Foundry to this effect and will submit all pertinent details and radiographs to Foundry. Procedure will then be carried forward as specified under subheadings (a) and (b) under (2) above.

*St. John X-Ray Service, Inc., Long Island City, N. Y.

Heat Balance Analysis for Air Conditioning

By **Louis A. Harding***

IT is instructive—and serves the useful purpose of checking the various calculations involved in the design of a comfort cooling installation—to spend an additional few minutes to make up a heat balance. As a matter of fact, some may prefer the heat balance method of analysis, as the chance for error is less.

Based on the conservation law, assuming steady flow operation of the apparatus, we know that the total energy of various kinds entering a system must equal the total energy leaving the system in unit time. Employing the heat equivalent of the various kinds of energy involved, we may express this law in the form of a heat balance; that is to say, the total equivalent heat entering and leaving a system must be equal in amount.

The following nomenclature is employed in this article:—

The heat balance method of analysis for comfort air conditioning — as contrasted with the method of individual differences usually employed—is explained here, illustrated by a typical example worked out in detail.....A table of properties of refrigerants and forms for recording computations are shown

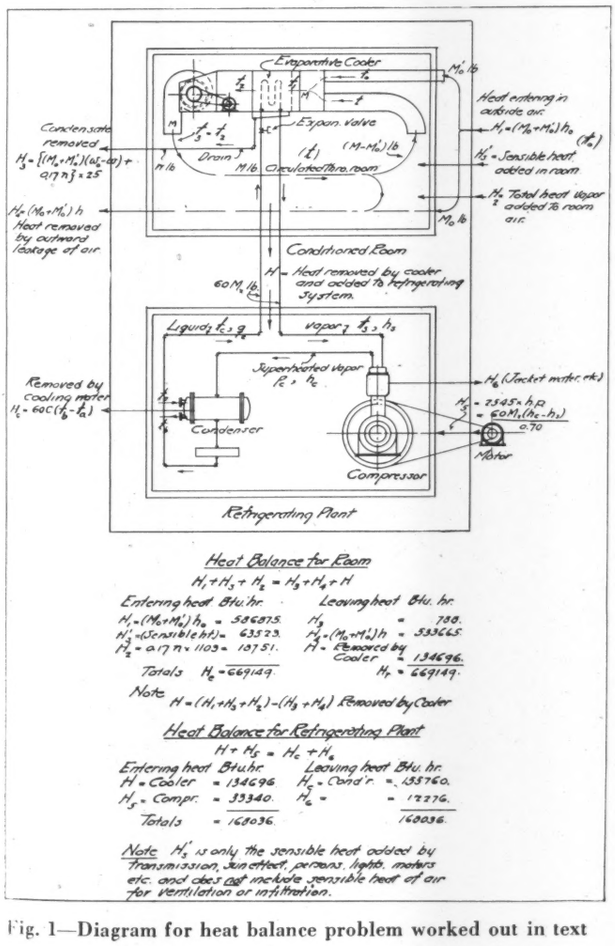

Evaporative Cooler
Heat entering in outside air
Condensate removed
Expan. Valve
Drain
Circulated thro room
Heat removed by outward leakage of air
Total heat vapor added to room air
Conditioned Room
Heat removed by cooler and added to refrigerating system.
60 M, lb
Liquid
Vapor
Superheated vapor
Removed by cooling water
Condenser
Compressor
Motor
Refrigerating Plant
Heat Balance for Room
H1+H3+H2 = H5+H4+H
Entering heat Btu/hr.
H1-(M0+M'0)h0 = 586875.
H'5-(Sensible ht)= 63523.
H2 = 0.17n×1103 = 18751.
Totals H = 669149.
Leaving heat Btu. hr.
H5 = 788.
H4=(M0+M'0)h = 533645.
H - Removed by Cooler = 134696.
H = 669149.
Note H=(H1+H3+H2)-(H5+H4) Removed by Cooler
Heat Balance for Refrigerating Plant
H+Hs = Hc+He
Entering heat Btu/hr.
H - Cooler = 134696
Hs - Compr. = 33340.
Totals = 168036.
Leaving heat Btu. hr.
Hc - Condr. = 135760.
He = = 17276.
168036.
Note H'3 is only the sensible heat added by transmission, sun effect, persons, lights, motors etc. and does not include sensible heat of air for ventilation or infiltration.

Fig. 1—Diagram for heat balance problem worked out in text

H_s = Sensible heat to be removed from room by cooler, Btu per hr. This includes the sensible heat to be removed from the air entering room by infiltration (not ventilation air).

M = Weight of air to be circulated through room by fan and through cooler, lb per hr.
$= H_s/0.24(t - t_3)$ lb per hr, in which t = room temperature and t_3 = temperature of chilled air entering room.

H'_s = Sensible heat to be removed from room, *excluding* infiltration, Btu per hr.
$= H_s - 0.24\ M_o(t_o - t)$, where t_o = temperature of outside air.

H_1 = Heat in air entering for ventilation and by infiltration, Btu per hr.
$= (M_o + M'_o)h_o$, where h_o = total heat per lb of outside air corresponding to outside dry bulb temperature t_o.
$(M_o + M'_o)$ = weight of air entering for ventilation and infiltration, lb per hr.

H_2 = Total heat in saturated vapor added by persons in room, Btu per hr.
$= 0.17n \times 1103$, in which n = number of persons; 0.17 = moisture loss per person, lb per hr (80 F air); 1103 = total heat saturated vapor at body temperature.

H_3 = Heat removed in W lb of condensate from cooler, Btu per hr.
$= Wq$, where $W = 0.17n + (M_o + M'_o)\ (w_o - w)$ and q = heat of liquid at temperature of condensate (approx. 25). w, w_o = weight of vapor per lb of inside and outside air respectively, lb.

H_4 = Heat removed by outward leakage of air from room, Btu per hr.
$= (M_o + M'_o)h$

H = Heat removed by cooler, Btu per hr.
$= M\ (h_1 - h_2)$, in which M is the weight of air circulated through room, lb per hr. h_1, h_2 = initial and final total heat of air entering and leaving cooler, Btu per lb (previously determined).

By the heat balance method of analysis, H is determined by difference as indicated by the equation.

$$H = (H_1 + H'_s + H_2) - (H_3 + H_4) \qquad \text{(See Fig. 1)}$$

H_5 = Heat equivalent of entering work for compressor, Btu per hr.
$= 2545 \times$ brake hp compressor motor.

$$\text{Brake hp, compressor,} = \frac{60M_x(h_c - h_s)}{\phi \times 2545} = \frac{M_x\ (h_c - h_s)}{42.5\ \phi}$$

ϕ = Overall potential efficiency of compressor (approx. 0.65 to 0.70).

M_x = Weight of refrigerant circulated, lb per min., = tons $\times$ $200/h_s - q_c$. h_c = total heat of superheated refrigerant vapor leaving compressor, Btu per lb; h_s = total heat of vapor at beginning of compression, Btu per lb, frequently assumed as the total heat of saturated vapor corresponding to the temperature of evaporator, t_s; q_c = heat of liquid, Btu per lb, usually assumed as that corresponding to the saturation temperature, t_c, corresponding to the pressure p_c maintained in the condenser.

*L. A. Harding Construction Corp., Buffalo, N. Y.

AIR CONDITIONING CORP'N. Form 100
Anywhere, U. S. A.

File .....
Date .....

Computations for Summer Cooling

Project .....

Design Conditions:

Outside air. t_o = ...° w.b.....° r.h.....% d.p.....° w_o.... h_o....
Inside air. t = ...° w.b.....° r.h.....% d.p.....° w .... h ....
Entering room air. d.b. = ...° t
Ventilation..... (n no. persons) x (10 to 15) =.....cfm. M'_o = ...lb per hr
Infiltration. (exhaust fans, etc.).....cfm. M_o = ...lb per hr
Shaded sides of building. ..... (sun effect *nil*)
Current available. .....cycle.....ph. .....volts.
Temp. cooling water available. t_a.....°

Heat Entering Room, Btu per hr (H_e)

Transmission

Outside walls .....(sq ft) x.....(unit trans.) x.....(temp. diff) = ...
Inside part'ns .....(sq ft) x.....(unit trans.) x.....(temp. diff) = ...
Glass .....(sq ft) x.....(unit trans.) x.....(temp. diff) = ...
Ceiling .....(sq ft) x.....(unit trans.) x.....(temp. diff) = ...
Floor .....(sq ft) x.....(unit trans.) x.....(temp. diff) = ...

Sun Effect, Glass

South wall .....(sq ft) x..... = ...
East wall .....(sq ft) x..... = ...
West wall .....(sq ft) x..... = ...
Skylights (inside shades).....(sq ft) x..... = ...
Sun Effect, Roof.....(sq ft) x..... = ...

(NOTE: Do not include both sun effect and transmission for same surface. Awnings reduce sun effect for glass by 28%).

Persons .....(no.) x 225 (sensible heat 80 F) = ...
Lights .....total watts x 3.41 = ...
Motors .....total hp x 2545 = ...
Electrical appliances .....total watts x 3.41 = ...
Steam piping, insulated .....sq ft x 90 = ...
Miscellaneous sources of heat..... = ...
Vapor from persons.....(no. persons) x 1103 = ...

Total for H'_s = ...
Ventilation .....(M'_o) x.....(h_o) H_v = ...
Infiltration .....(M_o) x.....(h_o) = ...

Total heat entering room, H_e = ...

Fig. 2—Form for recording comfort cooling computations

Fig. 3—Form for recording comfort cooling computations

Heat Leaving Room, Btu per hr, (H_r) Form 100-1

Outward Leakage Air.....lb ($M_o + M'_o$) x .....(h) H_4 = ...
Cooler Condensate..... { ($M_o + M'_o$) ($w_o - w$) + 0.17H } x 25 H_3 = ...

$H_3 + H_4 = H_r$ = ...
Heat removed by Cooler (and refrigerant).....$H_e - H_r = H$ = ...
Tons Refrigeration.....$H \div 12{,}000$ = ...
Air to be Circulated.....($H_e - H_v$) ÷ 0.24 ($t_3 - t$) lb per hr M = ...
Volume air circulated per min.....$M \div (60 \times 0.075)$ cfm = ...
Resistance, in. water..... " filter + ... " cooler + ... " heater (if any) + ... " duct system ..... = ...
Air horsepower .....(..... " (res) x 5.2 x cfm) ÷ 33,000, Ahp = ...
Fan brake horsepower.....Ahp ÷ 0.65 = ...
Fan motor (hp rating)..... = ...

Refrigerating Apparatus and Evaporator Coil

Recirculated air entering cooler, lb per hr.....$M_r = M - M'_o$ = ...
Dry bulb temp. air entering cooler.....$t_1 = (M_r t + M'_o t_o) \div M$ = ...
Moisture enter'g. cooler, per lb air.....$w_1 = (M_r w + M'_o w_o) \div M$ = ...
Dew point temp. air entering cooler.....(corres. to w_1) = ...
Wet bulb temp. air entering cooler.....(from psych. chart) = ...
Total heat per lb air ent'g. cooler.....(corres. to w.b. temp.) h_1 = ...
Total heat per lb air leaving cooler.....$h_2 = h_1 - H/M$ = ...
Tube rows depth of cooler..... = ...
Face area cooler.....(sq ft) (cfm ÷ velocity, fpm) = ...
Temp. refrigerant req'd. (See chart)..... (t_s) = ...
Total heat per lb refrigerant sat'd vapor for t_s .....(v_s = ...) h_s = ...
Condenser .....p_c = ...lb per sq in. t_c = ...° q_c = ...
Total heat superh't'd. vapor at p_c.....(tot. ht. — entropy cht.) h_c = ...
Weight refrigerant pumped per min....M_x = (tons × 200) ÷ ($h_s - q_c$) = ...
Compressor displacement.....$D = M_x v_s \div 0.75$ cfm = ...
Compressor hp .....$M_x (h_c - h_s) \div 42.5 \phi$ = ...
Compressor motor. (hp rating)..... = ...
Cooling water. Initial temp. t_a.....° Final temp. t_b.....°
Cooling water req'd. lb per min (C).....$M_x (h_c - q_c) \div (t_b - t_a)$ = ...
Cooling water, gph.....$60C \div 8.34$ = ...
Condenser surface req'd., sq ft. Type..... = ...
Cost of current per hr, cents..... = ...
Cost of water per hr, cents..... = ...

NOTES:

H_c = Heat removed by condenser, Btu per hr.
= $60C(t_b - t_a)$; C = weight of water, lb per min; t_a and t_b, initial and final temperature of cooling water.
H_o = Heat removed by compressor jacket water, radiation and convection from apparatus, Btu per hr.

Applying the heat balance method of analysis to the problem given in the July, 1935, H. P. & A. C., pp. 317-322, we note that the sensible heat (H_s = 91,363) that must be absorbed by the circulated air (M) includes the sensible heat to be removed from the air entering by infiltration, or 0.24 ($t_o - t$) M_o or 0.24 x 10 x 11,600 = 27,840 Btu per hr.

Then H'_s = 91,363 — 27,840 = 63,523 Btu per hr.

The total heat for the outside air, h_o = 37.5 and for the inside air, h = 34.1 Btu per lb air.

$H_1 = (4050 + 11{,}600) \times 37.5 = 586{,}875$ Btu per hr.
$H_2 = 0.17 \times 100 \times 1103 = 18{,}751$ Btu per hr.
$H_3 = 31.5 \times 25 = 788$ Btu per hr.
$H_4 = (4050 + 11{,}600) \times 34.1 = 533{,}665$ Btu per hr.

Then $H = (H_1 + H'_s + H_2) - (H_3 + H_4) = 134{,}696$ Btu per hr. or Tons Refrigeration = 134,696/12,000 = 11.2, as previously computed.

The heat balance for the room is shown by Fig. 1. The computations in the July article gave the following results:

Compressor brake hp = 13.1; Cooling water C = 88 lb per min.
Then $H_3 = 2545 \times 13.1 = 33{,}340$ Btu per hr and
$H_c = 60 \times 88\ (99.5 - 70) = 155{,}760$ Btu per hr.

Table 1—Properties of Refrigerants

[Pressures are absolute; temperatures, degrees Fahrenheit; Heats, q_c, h_s and h_c, Btu per lb; d=density liquid, lb per cu ft; v_s=specific volume saturated vapor, cu ft per lb; h_c for no superheat in suction as read from Mollier diagrams.]

AMMONIA (NH_3)

Saturated Vapor Evaporator (h_s)					Condenser (h_c)		
					t_c=82.6°	86°	96.3°
					p_c=160	169.2	200
t_s	p_s	d	v_s	h_s	q_c=135	138.9	150.9
—10	23.7	41.8	11.50	608.5	728	730	745
0	30.4	41.3	9.12	611.8	716	719	732
10	38.5	40.9	7.30	614.9	703	706	719
20	48.2	40.3	5.91	617.8	691	694	707
30	59.7	40.0	4.83	620.5	680	683	695
40	73.3	39.5	3.97	623.0	670	672	684

CARBON DIOXIDE (CO_2)

					t_c= 70°	80°	86°
					p_c=860	960	1020
t_s	p_s	d	v_s	h_s	q_c=65	75	84
—20	215	0.0149	0.417	138.5	164	167	168
0	366	0.0157	0.290	138.9	155	157	159
10	360	0.0161	0.244	138.7	152	154	157
20	422	0.0166	0.205	138.3	149	151	153
30	491	0.0172	0.172	137.8	146	148	149
40	568	0.0178	0.144	136.7	142	144	145

METHYL CHLORIDE (CH_3Cl_2)

					t_c=80°	100°	120°
					p_c=85.3	118.8	159.6
t_s	p_s	d	v_s	h_s	q_c=41.7	49.4	57.5
0	18.8	61.9	5.18	193.6	224.9	232.0	238.0
10	23.3	61.3	4.18	194.9	222.2	229.5	235.7
20	28.8	60.7	3.41	196.3	219.4	226.8	232.5
30	35.2	60.1	2.81	197.6	217.0	223.9	230.0
40	42.6	59.5	2.31	198.9	214.4	221.0	227.0
50	51.5	58.7	1.93	200.2	212.0	218.5	224.5

"FREON" (DICHLORODIFLUOROMETHANE) (F-12) (CCl_2F_2)

					t_c=80.9°	93.4°	104.5°
					p_c=100	120	140
t_s	p_s	d	v_s	h_s	q_c=26.50	29.54	32.38
0	23.9	90.5	1.64	78.21	89.4	90.7	92.0
12	30.6	89.2	1.30	79.59	88.9	90.1	91.4
20	35.8	88.4	1.12	80.49	88.5	89.8	91.1
30	43.2	87.2	0.94	81.61	88.1	89.5	90.6
40	51.7	86.1	0.79	82.71	87.8	89.2	90.3
50	61.4	84.9	0.67	83.78	87.6	88.9	90.1

Saturated Vapor — Superheated Vapor

The heat balance indicates that the estimated heat removed in compressor jacket water, by radiation and convection, to be

$$H_0 = 12{,}276 \text{ Btu per hr.}$$

A systematic record of the computations involved for a proposed comfort cooling installation is obviously essential in any well regulated office.

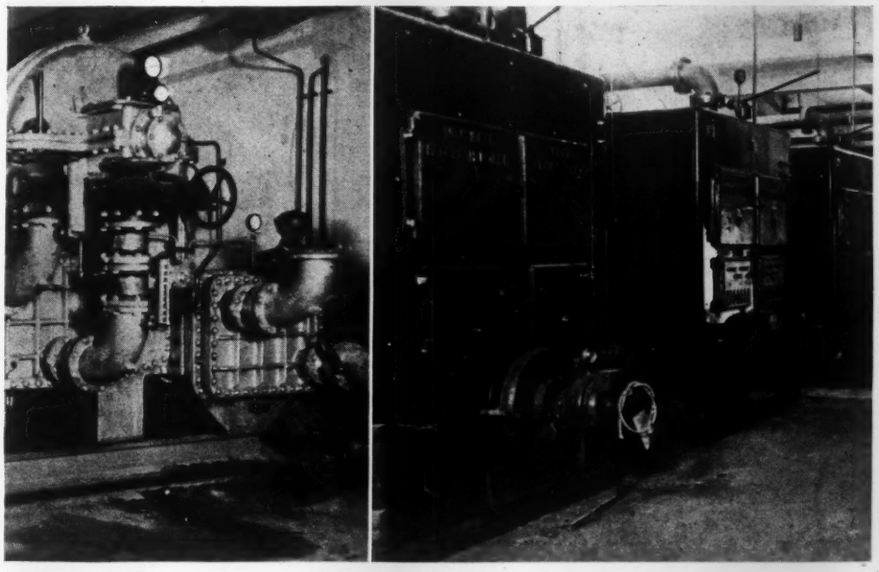
The forms presented here may be used to advantage and include the engineering data required to determine the capacity of the various apparatus. They are easily followed and require the use of unit heat transmission tables, psychrometric chart, a diagram, tables or formula for determining the temperature of refrigerant and a total heat-entropy diagram for the refrigerant to be employed. (See July, 1935, H. P. & A. C., pp. 317-322, and September, 1935, pp. 429-433.) The accompanying table on properties of refrigerants may be employed for determining v_s, h_s, h_c, and q_c by interpolation, in place of the total heat—entropy charts published in September. For number of rows of evaporator cooling coils and temperature of refrigerant, see chart, pp. 386-387, August, 1935, H. P. & A. C.

Those who prefer to use the method of differences for various items in computing the tons of refrigeration may easily revise the few lines necessary to accomplish the result. The back of one sheet may appropriately be filled with transmission data, etc. and the other, cross section lines for a diagrammatic sketch of the proposed layout.

[This is the third of Mr. Harding's series of three articles on comfort air conditioning.—THE EDITOR.]

U. S. Equipment Air Conditions Montevideo Bank Building

By **Rudolf Kuhlmann***



***Left*—Two 250 hp centrifugal compressors supply refrigeration for air conditioning the Banco de la Republica Oriental del Uruguay. *Right*—Three of the six oil-fired cast iron boilers**

MONTEVIDEO may boast the most impressive collection of North American heating, ventilating and air conditioning equipment in South America in its Banco de la Republica Oriental del Uruguay. The first section of this bank, which is really a combination bank and office building, was finished over three years ago and the remainder was under construction when I visited Montevideo earlier this year. With the exception of the necessary ductwork, grilles, additional washers and accessories, all the major equipment for the entire building was installed when the first part was built.

Two 250 hp centrifugal compressors supply refrigeration for air cooling. Only one of these was being used, as the second was to be called into service upon completion of the building. Three washers were in operation, and three more were being erected.

Six cast iron heating boilers, each rated at 500,000 Btu, formed an imposing battery of steam producers. Each was protected with a low water cut-off. Six semi-automatic fuel oil burners fire these boilers, and constitute the first large semi-automatic fuel oil burning installation in South America. Two mechanical cooling towers erected on the roof of the bank avoid the expense of using the city supply for condenser water. These are enclosed, spray type coolers, and each fan is equipped with a 15 hp motor.

There was not a single conventional type radiator in the building, and the engineer said there were no steam pipes above the basement. Both heating and cooling are accomplished by air distribution through ducts from the central boilers, compressors, washers and heat transfer surface. It was interesting to observe that all steam mains were of brass.

It was interesting to me to note that the compressors, boilers, low water cut-offs, oil burners, cooling tower fans and their motors and other equipment were of U. S. manufacture; a cursory inspection of the control equipment showed that at least five U. S. firms were represented by the controls, indicators, and recorders for temperature, pressure, and humidity. Actual installation of the job was done by the local subsidiary of a large U. S. corporation.

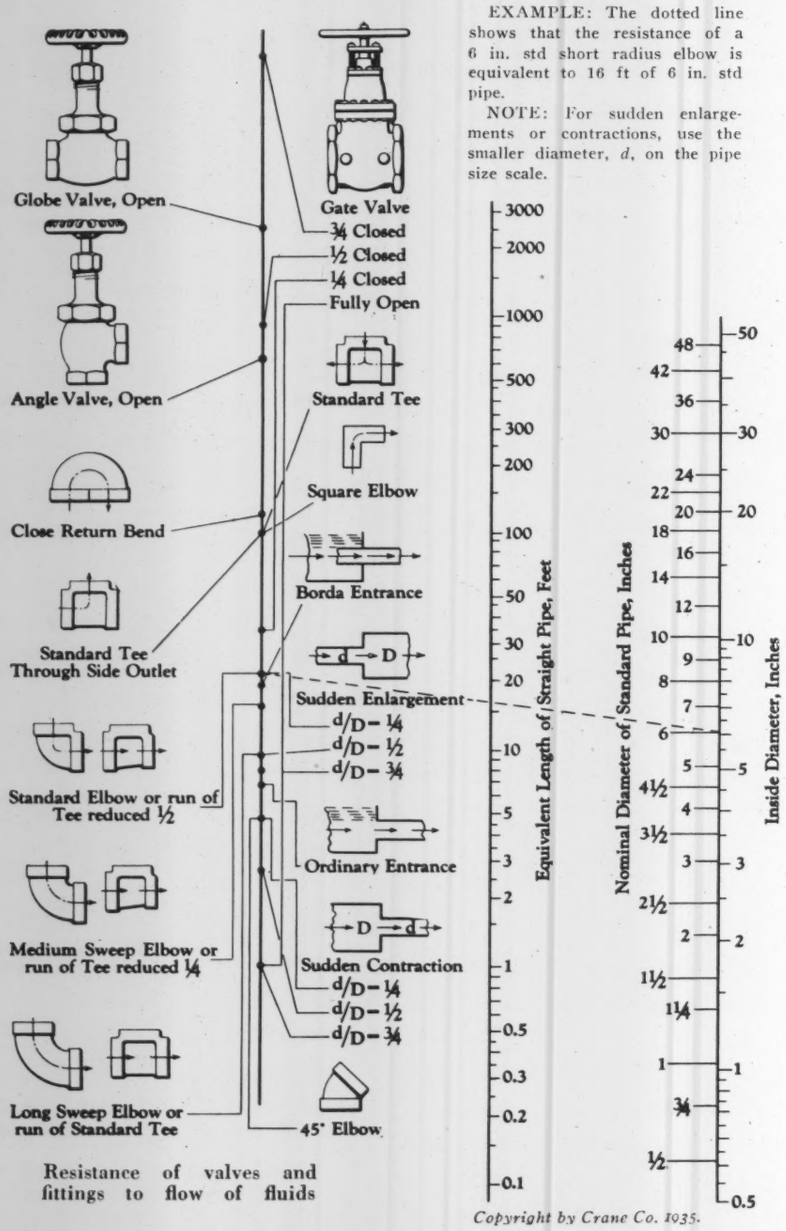
*Engineer, New York, N. Y.

Resistance of Valves and Fittings to Flow of Fluids

TO obtain definite data on the resistance of valves and fittings to the flow of fluids, pressure drop tests have recently been conducted on both steam and water for 2 in. and 6 in. sizes and are described in detail in the booklet "Engineering Data on Flow of Fluids in Pipes and Heat Transmission." [1] The steam tests were made on pressures of 50 and 100 lb, velocities 2,000 to 20,000 fpm. The water tests were made with a 3 in. test line with inlet pressure kept constant at 80 lb and rate of flow varied by throttling the test line outlet.

The figure shown here is based upon these tests and information gathered from other sources, and gives the equivalent length of pipe to produce the same pressure drop as a valve or fitting; this additional length should be added to the length of the line in order to determine the total pressure drop. Pressure drop caused by the *length* of the valve or fitting is disregarded, the figure giving just the pressure drop *added* by the presence of the article in the line. For instance, if a valve 4 in. face-to-face is installed in a line 30 in. long, the actual pressure drop through the valve will be the total pressure drop minus the drop caused by 26 in. of pipe. However, in a practical problem this value will be added to the pressure drop caused by the total length of line which will give a pressure drop slightly higher than the actual. This "no length" concept was established and has been used before with reference to elbows by Prof. F. E. Giesecke.

[1] Published by Crane Co., Chicago, Ill.; see review in "Booklets, Reports, and Papers," this issue. Data reproduced by special permission.



Resistance of valves and fittings to flow of fluids

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Results of Tests

Briefly, the tests on water indicated that globe valves offer a resistance to flow greater than shown by previously published data; screwed and flanged globe valves and fittings of the same design offer equal resistance to flow; 2 in. globe valves installed with pressure under the disc cause a greater pressure drop than do the same valves with pressure on top of the disc, and 2 in. welding elbows show lower pressure drop than screwed long sweep elbows.

The steam tests indicated that 6 in. globe valves with pressure on top of the disc cause a greater pressure drop than when installed with pressure under the disc, while 2 in. globe valves with pressure under the disc cause a greater pressure drop than with pressure on top of the disc.

Pressure drop through pipe is approximately inversely proportional to the specific volume of the steam (assuming a constant friction factor) if the velocity is the same; *i.e.*, if the pressure drop is known at 50 lb gage (specific volume 6.65) the pressure drop at 100 lb gage (specific volume 3.88) will be approximately 6.65/3.88 or 1.72 times the drop on 50 lb pressure with the same steam velocity. The tests on 100 lb steam indicated that the same relation exists for valves and fittings as for pipe.

In general, the tests showed that the pressure drop through 2 in. globe valves on steam in terms of equivalent pipe length is greater than the resistance offered by the same valves to the flow of water when expressed in the same terms. The actual values are—steam, approximately 75 ft of 2 in. pipe, and; water, approximately 60 ft. It is assumed, however, for practical purposes that the resistance offered to both steam and water flow is the same when expressed in terms of an equivalent length of pipe.

PRACTICAL HEATING

By **Harold J. Taylor***

Installing Indirect Hot Water Heaters

Automatic arrangements for domestic service hot water are imperative for low cost of operation; where oil or stoker fired boilers are used, the hook-up of storage tank to an indirect heater affords an ideal method applicable to apartments, hotels, factories, schools, hospitals, residences, etc. The following data will be helpful in selecting and installing the proper equipment for this type of job.

Tapping the Boiler—Sectional steam boilers must be provided with a tapping in each section (except front section) and the combined tappings must be connected with pipe to a manifold which is connected to the indirect heater. Tappings should be 3 in. below the normal boiler water line. On steel boilers it is necessary to tap only one opening, which may be secured by welding a nipple or coupling into the boiler; on round boilers it is necessary to tap only one section.

Many of the steel and round cast iron boilers made in recent years are provided with this opening.

Before deciding on the drilling and tapping, determine if water line drops in glass when boiler is under normal operating conditions. I have seen a number of cases where this condition existed and the water in the boiler being below the pipe pieces in the manifold would prevent circulation of boiler water through the heater; in this event tap and drill 2 or 3 in. below operating water line level. The manifold must be kept as high as practical, as must the indirect heater, so that the hottest water from the boiler will be adjacent to the heater.

Many boiler manufacturers will tap all sections on new sectional boilers at nominal cost. Usually the back section of all recently manufactured boilers is drilled and tapped; if the other proposed openings are lined up with this tapping, one drilling and tapping will be saved. If the back tapping is lower than the 3 in. required, it should be re-tapped.

In tapping any boiler, be sure that you are drilling into the cored part of the section. Set the pilot drill so it will not be possible to drill into the opposite wall of the cored section. After the hole is drilled with the pilot drill, insert a wire with an offset in it and feel around inside of the section. If a stave is found within this area, then it may be wise to move over to a new location, tap out the hole made by the pilot drill and plug it up.

On some types of boilers, all sections need not be tapped, as an extra large nipple construction is incorporated at top of boiler and a portion of the boiler water is circulated throughout the entire length of the boiler. In other words, it is the same as raising the water level in sectional boilers when only a few of many sections are tapped. This is explained in the following paragraph.

On an installation where all the sections are not tapped, or on a boiler with split sections (that is, where the two halves of the boiler are connected to each other only by the upper nipple ports or by headers as furnished by the manufacturer) the boiler should be filled with water during the summer months so that the upper nipple ports or header are half full. For the convenience of the boiler attendant, a ½ in. pipe line should be installed to a point approximating the center of the upper nipples or header, with a valve on the end. When attendant is about to flood the boiler he may open valve and fill until water shows at the top of valve. This high water level will cause the water in the two half sections of the boiler to circulate over the entire length of boiler.

On unattended split sectional boilers it is vitally necessary, if the boiler is to be used for summer firing, to tap each of the half sections and to install two manifolds (one on each side of boiler). These two manifolds are tied together into a neutral pipe line to the supply tapping of the indirect hot water heater. The reason for this is obvious, as the owner cannot be expected to raise and lower the boiler water level to meet varying weather conditions. Where an engineer or attendant is employed he can be expected to raise and lower the water level as required, and then the double manifolding is not absolutely necessary.

If the manifold header is likely to become air bound due to the type of hook-up used, a ½ in. line should be installed from the top of manifold into the steam space above the water line of the boiler. In case the water is carried high in the summer, then be sure the ½ in. venting line is connected high enough so as to be in the steam space. In venting the manifold, tie the vent line into the water column (if of the outside type) or below pop valve or damper regulator opening. The manifold may be made up of steel pipe and cast iron fittings, or welded, or preferably of copper tubing and brass or wrought copper fittings.

If the indirect heater should have, for example, a 1½ in. shell opening and the boiler is to be tapped on five sections, then the combined tapping areas should equal or exceed the area of the manifold size. In this instance we would tap the sections 1 in. I would not suggest tapping any boiler section less than 1 in. in any case. This precautionary measure will allow for possible fouling of the pipe or tubing. The shell and coil openings on the indirect heater should be full size, however; with copper tubing or brass pipe, use one size smaller.

Control—A gate valve should be installed in the return piping from the indirect heater to the return opening of the boiler to be used to reduce the flow of water through the heater which will, in turn, tend to prevent too high temperature of the water in the storage tank. It is only during the heating months that this valve will be throttled down and in the summer the valve is left wide open. There are automatic devices that will take care of this condition very nicely which are inexpensive and easy to install.

To maintain temperature in the steam boiler below the steaming point, it is necessary to install an aquastat in the manifold or top of indirect heater. The installation of the aquastat is simple and it is usually wired up to the pressure control unit or relay unit.

*Contracting Engineer, Detroit, Mich.

Tank Size—Storage tank size has an important bearing. It is essential that a tank of ample size be used, in no case under 50 gallons. Up to 65 gallons' capacity, it may be stood in a vertical position (though preferably horizontal) but over this it should be horizontal. Bottom of tank must be above top of indirect heater.

Use of Pump—On old jobs where the tank has been connected to an indirect heater and the heating effect of the water is poor, owing to the fact that the bottom of the tank is appreciably below the top of the indirect heater, I would suggest the installation of a recirculating pump. However, if changing the position of the tank is possible and practical then it may be advisable to alter the tank setting. If the pump is to be used, then it is necessary that the indirect heater be installed at a point where its top will be below the bottom of the tank. With this arrangement it does not matter how low the heater is placed, for it does not rely on gravity circulation. The supply to the heater from the boiler must be in the same position in regard to the water line level as in a gravity job.

The recirculating pump is installed in the return piping from the indirect heater to the steam boiler and operation of the pump is controlled by an aquastat. This aquastat (in addition to the one in the manifold) is installed at a point near bottom of storage tank and will control the temperature and volume of stored hot water.

The capacity of an indirect heater is increased approximately 25 per cent when used in connection with a recirculating pump of proper size. Piping sizes may be reduced approximately 75 per cent between the indirect heater and the steam boiler when a pump is used, excepting for the pipe pieces between the boiler and the manifold which should not be less than 1 in.

Heater Size—On old jobs where tank capacity is short, be sure to figure heater size based on the amount of gallons required and not tank size. To estimate size of recirculating pump in gallons of boiler water to be handled, figure to pump 1⅓ gallons of boiler water for each gallon of service hot water raised 33⅓ F per hr. If the heater capacity were based on raising the temperature of the service hot water 100 F per hr, then the pump would be selected on the basis to pump 4 gallons of boiler water for each gallon of service water heated.

When selecting an indirect heater for a given job, it is very necessary that the size be based on the hot water demand and not on the size of storage tank installed. Automatically fired boilers for summer and winter use require a much larger size indirect heater than do coal hand fired boilers. For capacities of heaters and storage tank sizes, refer to manufacturers' data books.

On jobs where a recirculating line is connected to the storage tank, add ⅓ to the indirect heater size.

Vent Valve—On steam boiler jobs where the supply and return mains are valved at the boiler and are closed for summer operation, a pressure of air and not steam may be encountered. If this is the case, install a quick vent valve (not of the vacuum type) with a tight fitting globe valve just below it (providing that the job is of the vacuum type—valve to be closed during the heating season) at some convenient point between the steam space of the boiler and the main supply valve.

Stoker Fired Jobs—I have found it impractical to connect a stoker fired job without the use of valves on both the supply and return mains. It has been my experience that even though the boiler is kept in a flooded condition, steam is formed by the carry-over of the stoker fire after the stoker is stopped. I have corrected several jobs where the steam from the boiler had reached even to the radiators on the first floor of large installations, and therefore suggest the installation of valves in all cases where a stoker is involved.

Boiler Capacity—Boiler capacity must be considered, particularly on large jobs. Quite often the owner desires to take the hot water load off his present heater and add it to the steam heating boiler through the installation of an indirect heater. In this case I would be careful to check the heating requirements of the building. Then I would proceed as follows:

Check the requirements of hot water demand against the size and capacity of the storage tank.

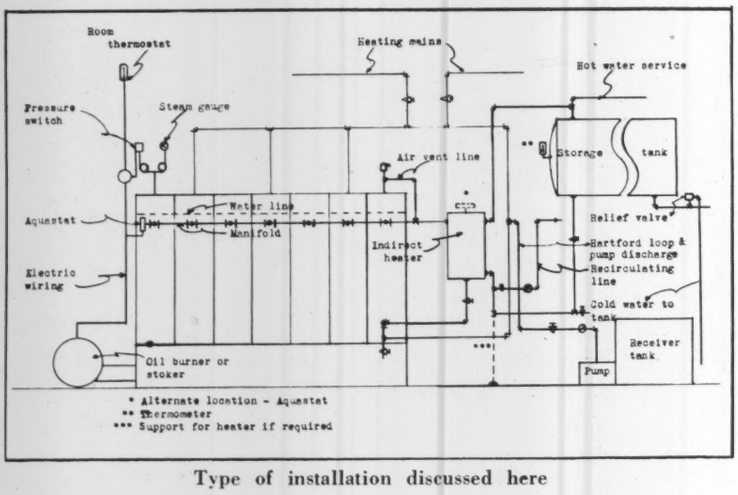
Assuming that the capacity of the storage tank and indirect heater as selected are ample for the job then allow ½ sq ft of boiler load tax for each gallon of water to be heated and stored based on 100 F rise in 3 hr.

Allow 1½ sq ft of boiler load tax for each gallon of water to be heated and stored, based on 100 F rise in 1 hr.

When an indirect heater is installed above the water line of the boiler, allow 2½ sq ft of boiler load tax for each gallon of water to be heated.

An indirect heater should be installed above the water line of a boiler only when there is to be a continuous supply of steam available.

Hot Water Systems—On hot water heating systems, the indirect heater may be used with equal results but the installation is quite different from that for steam. Several manufacturers are providing a combination of flow valves and booster (recirculating) pump. With this type of equipment a flow valve is installed in both the supply and return lines to the boiler. The pump is installed in the return line to the boiler and is connected electrically to a thermostat in the living quarters. The supply opening of the indirect heater is taken from the flow line to the radiators at a point just above the opening of boiler. This flow line should be taken from an opening on top of boiler as far away as possible from where the return from the heating system enters the boiler. This will prevent possible short circuiting of cool return water passing into the hot water supply line to the radiators.



Type of installation discussed here

Air Conditioning for Motor Buses Announced; System Described

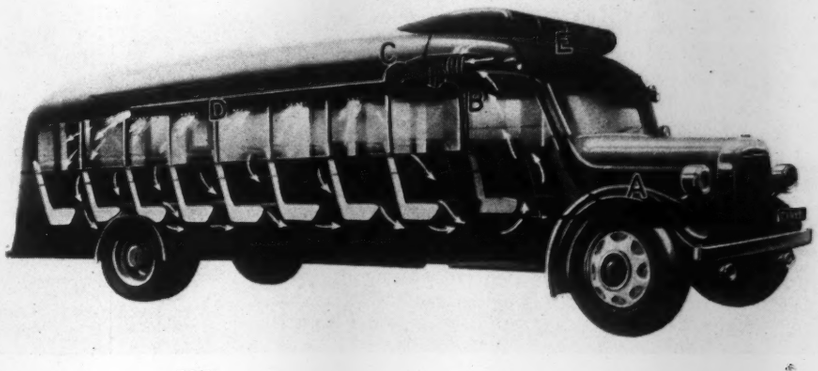
Ralph F. Peo about to enter test car used as "proving ground" for development of motor vehicle air conditioning, and which has been driven over 12,000 miles during the process. The coil on top is the condenser, intended for use primarily on buses

A NEW application of air conditioning—the private automobile, taxicab, ambulance, and motor bus—was described to members of the *National Association of Motor Bus Operators* assembled in New Orleans October 25, and it was predicted that air conditioning will soon offer the automotive industry the advantages it has given the railroads in stimulating traffic and increasing revenue. Development by Ralph F. Peo of Houde Engineering Corp. and E. P. Heckel of Carrier Engineering Corp. of a method for air conditioning self-propelled motor vehicles was announced. No doubt was expressed that air conditioning will pay its way in the bus industry as it has in railroad cars, theaters, stores, shops and a host of other applications. Private cars with "weather control" were foretold.

The system utilizes a low pressure compressor similar to a rotary type driven by the bus engine and charged with about a gallon of "Carrene," an evaporator within the bus, a small motor driven fan distributing air through ducts along each side or down the center of the passenger compartment. The air cooled condenser, mounted outside the passenger compartment, may be kept less than 15 in. high, streamlined to harmonize with the vehicle design.

Tests have indicated air distribution of approximately 1500 cfm, or about 50 cu ft per passenger with 25 per cent outside air to dissipate odors and dilute smoke. Assuming a typical long haul bus seating from 32 to 35 passengers and with interior dimensions 26 ft long, 7 ft wide and a maximum height of 6 ft, 9 in., cubic content will be about 1200 cu ft, external body surface 630 sq ft and glass surface 115 sq ft. With good tight construction, roof insulated and properly painted, the cooling load is estimated at 60,000 Btu per hr, or 5 tons of refrigerating capacity. Heat given off by 35 passengers is figured as 14,000 Btu per hr, and the air drawn in for ventilation and infiltration represents 12,000 Btu. Sun load, heat from the engine, and infiltration of outside unconditioned air are the most important factors entering into the cooling load; consequently adequate insulation becomes important.

The apparatus thus far developed indicates that a system to care for such a bus will weigh less than 600 lb, require less than 6 hp to operate, occupy a combined space of less than a 3 ft cube, and cost a negligible sum to operate.



Diagrammatic sketch of proposed air conditioned bus. Compressor *A* driven by car engine supplies refrigerant to cooling coil *B* provided with intake and filter for outside air. Fan *C* draws air over coil, where it is cooled and dehumidified, then distributed through duct *D*; outlets in bottom of duct diffuse conditioned air downward over passengers. *E* is the condenser cooling coil

Handling Fuel Oil from Tank Car to Burners

By **Kalman Steiner***

FUEL oil must be mechanically handled in practically all phases of its use and its adaptability to mechanical handling constitutes one of its advantages. In general, there are two occasions for pumping fuel oil in the average industrial plant—unloading from railroad cars into storage tanks, and transferring oil from storage to the burners through intermediate heaters, pressure regulators, strainers, etc. Small plants and most commercial buildings purchase oil in less than carload quantities; in this case, of course, it is delivered into storage by tank truck, and only the latter of the above mentioned operations devolves upon the user.

Transmission of oil through pumps and piping involves a number of subordinate operations, such as straining, pressure regulation, regulation of volume delivered to burners, and maintenance of correct fuel oil temperatures. Hence a fuel oil pumping and piping system logically begins at the storage tank and ends at the burners. Between is the equipment which establishes and maintains the fluid flow: pumps, piping, fittings, valves, heaters, strainers, pressure regulators, metering devices. Each contributes to delivering oil where and as needed and in the correct physical condition; each must thereafter be considered as part of a system, rather than as an independent or separate unit.

Types of Pumps

Fuel oil pumps can be generally classified as external gear or internal gear types. Both are encountered in a wide and diverse range of forms. Their designers try to achieve two ends—to provide for transporting oil, and to fashion gear surfaces and forms that will avoid congested regions within the pump where fluid is forced through small passages or apertures. In general, the internal type can be constructed at a lower cost than the equivalent external pump because less casing and less machine work are needed. Hence, for small oil burners, internal gear pumps are most popular, while larger pumps are usually of the external type. In the less expensive models of external gear, and almost always in the internal gear pumps, one of the gears is power driven while the other is turned by mesh with the driven gear and is called the idler gear. In the more costly types, especially of external gear pumps, both gears are power driven, being interconnected by a timing gear mechanism.

Too often the selection of a pump is predicated upon first cost, little thought being given to such matters as maintenance, ultimate life, and more especially, to power consumption. As a rule, the tendency for power consumption to increase out of proportion to good economy is greater as the pressure required increases, or, in other words, the feature of power consumption becomes increasingly important as the developed or required oil pressure rises.

Table 1—Speed—Viscosity table, showing relation between viscosity, pump speed, pump type, and pump size

Pump Type	External Gear Type						Internal Gear Type						
Capacity GPM.	35	50	100	200	300	600	5	20	50	90	200	300	450
Viscosity Saybolt Universal Seconds	Maximum Pump Speed, RPM												
50	1750	1150	850	500	400	300	1750	1150	400	390	375	300	260
100	1750	1150	850	500	400	300	1750	1150	400	390	375	300	260
200	1750	1150	850	500	400	300	1750	1150	400	390	375	300	260
300	1750	1150	850	500	400	300	1750	1150	400	390	375	300	260
400	1750	1150	850	500	400	300	1750	1150	400	390	375	300	260
500	1750	1150	850	500	400	300	1750	1150	400	390	375	300	260
600	1740	1125	830	490	395	295	1740	1125	395	385	370	295	256
700	1715	1100	810	480	390	290	1715	1100	390	380	365	290	252
800	1690	1075	790	470	385	285	1690	1075	385	375	360	285	248
900	1665	1050	770	460	380	280	1665	1050	380	370	355	280	244
1000	1640	1025	750	450	375	275	1640	1025	375	365	350	275	240
2000	1580	990	725	430	355	260	1580	990	355	350	334	260	230
3000	1520	955	700	410	335	245	1520	955	335	330	317	245	215
4000	1460	915	675	390	315	230	1460	915	315	310	300	230	200
5000	1400	875	650	370	295	215	1400	875	295	290	280	215	185
6000	1340	835	625	350	275	200	1340	835	275	270	260	200	170
7000	1280	795	600	330	255	185	1280	795	255	250	240	185	155
8000	1220	755	575	310	235	170	1220	755	235	230	220	170	140
9000	1160	715	550	290	215	155	1160	715	215	210	200	155	125
10000	1100	675	525	270	195	140	1100	675	195	190	180	140	110
20000	1000	600	500	250	175	120	1000	600	175	170	170	120	100
30000	900	525	450	230	170	110	900	525	170	165	160	110	90
40000	800	450	400	210	160	100	800	450	165	160	150	100	80

The speed at which rotary pumps should be operated is related to the viscosity of the oil being pumped and Table 1 shows the general relationship between these variables. Economy in power consumption will be heavily influenced by the speed, so that excessive speeds should be guarded against by providing pumps which will develop adequate capacity and pressure at nominal speeds, in accordance with these values.

The Suction Line

In the majority of heating plant oil burner installations, fuel is drawn from storage up to the pump by suction, thence to be delivered to the nozzle under some pressure which may be low or high, according to the burner type. Perhaps the most important feature of the suction line, aside from its being large enough, is that it be absolutely tight and free from air leaks. Regardless of the pump used, air leaking into the suction line universally produces ill effects in the pump and flow regulating mechanism; knocking and hammering, wheezing and sputtering, chattering and clattering, all occur in the pump and valves by reason of air drawn into the suction line. In turn these mean excessive pump wear, uneven oil pressure and fluctuating delivery. A tight suction line is the start of a good oil burner installation—a leaky one is its finish.

[This is the first of a series on this subject. Pump selection and piping design, pressure regulation, strainers, metering, and control are among the topics to be considered in succeeding issues. —The Editor.]

*Chief Engineer, Consumers Petroleum Co., Chicago, Ill.
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Chicago Air Conditioning Standards Ready; Results Emphasized

THE Chicago committee on air conditioning standards, representing a cross-section of the industry under the chairmanship of John Howatt, has just completed new standards for Chicago.* These standards, differing in form from those prepared last February, set up minimum requirements and emphasize the results to be attained. Following are the standards:

1. Scope: These standards are intended to set forth minimum requirements only. *Note*: By no means are they to be understood as limiting good practice or as preventing progress or invention.

2. Definition of Air Conditioning: For the purpose of these standards, Air Conditioning is defined as the process by which the temperature, moisture content, movement and cleanliness of the air in enclosed occupied spaces intended for human occupancy are maintained within definite required limits. *Note*: For purposes of public protection these standards recognize apparatus which performs:

(a) All of the above functions in winter.

(b) All of the above functions in summer.

(c) All of the above functions in all seasons.

If an installation does not perform all of these functions it shall be called by a name which describes only the function performed. For instance, neither a temperature controlling nor an air moving apparatus may be called an air conditioning apparatus.

3. Design Coefficients for Heat Transfer Through Construction Barriers and for Heat Gains from People or Appliances—shall conform to the standards recommended by the current issue of *The Guide, American Society of Heating and Ventilating Engineers.*

4. Minimum Standards for Refrigeration Apparatus—shall conform with the current issue of the *Refrigeration Data Book, American Society of Refrigerating Engineers.*

5. Minimum Design Temperatures and Humidities for Heating—shall be — 10 F outside and 70 F inside. The humidifying apparatus shall be designed to furnish at least 35 percent R. H. when the outside temperature is 30 F. *Note*: In buildings of ordinary construction a R. H. of 35 percent will cause sweating at outside temperature below 30 F.

6. Minimum Design Temperatures and Humidities for Cooling—shall be such as to cover both of the following conditions:

(a) Outside 95 F Db and 75 F Wb; Inside 80 F and 50 percent R. H. or equal effective temperature as determined from the summer comfort chart in *A.S.H.V.E. Guide.*

(b) Outside 80 F Db and 75 F Wb: Inside 78 F and 52 percent R. H. or equal effective temperature as determined from the summer comfort chart in *A.S.H.V.E. Guide.*

7. Infiltration and Leakage: Design capacity to care for infiltration of air from outside shall be provided in all heating systems in accordance with the latest issue of the *A.S.H.V.E. Guide. Note*: Nothing in these standards shall be taken as preventing an allowance for infiltration and leakage when cooling.

8. Design Load Calculations:

(a) For winter air conditioning shall include allowances for heat loss through:

(1) Physical barriers such as walls, doors, windows, ceilings, floors, etc.

(2) Infiltration.

(3) Outside air for ventilation by mechanical means.

(b) For summer air conditioning shall include pertinent allowances for heat gain from the occupied zone through:

(1) Physical barriers such as walls, doors, windows, ceilings, floors, etc.

(2) Outside air for ventilation by mechanical means.

(3) Sun heat.

(4) Heat and moisture from occupants.

(5) Heat and moisture from appliances, illumination, combustion, etc.

The basis of all of these allowances shall conform with the coefficients in the current issue of *The Guide, American Society of Heating and Ventilating Engineers,* except where these standards give other specific requirements.

9. Design Allowance for Shading from Sunshine—shall be made only when the plans and specifications specifically show such allowance, and when they give assurance that the owner is cognizant of the reduction in capacity on this account.

10. Design Air Quantity: If the heat is to be transported into the room or out of the room by the air, either when heating or when cooling, the quantity and temperature and moisture condition of the air must be such as assuredly to accomplish the work. In addition:

(a) The basis of design for heating equipment, air volumes, duct work and outside air connections shall be not less than the requirements of the Chicago Municipal Code.

(b) Summer air conditioning not covered by the Chicago Municipal Code when refrigeration or other cooling equipment is used, shall provide for the positive introduction of at least 10 cfm of outside air per stated occupant, and for restaurants, beauty parlors, rooms with heavy smoking, and other rooms with special sources of contamination, this shall be increased to a minimum of 15 cfm per stated occupant.

Where the occupancy is not known, or where the stated occupancy is below the Chicago City Code stipulation, the latter shall govern in determining occupancy.

*The air conditioning industry has recognized the necessity for standard minimum requirements that all branches of it would endorse, to eliminate as far as possible confusion created by the wide variation in capacities of equipment offered for specific applications. For this purpose a committee of nine was selected, each member representing a different technical society or association interested in air conditioning. The Chicago air conditioning standards are the result of this committee's deliberations. They may be revised from time to time as further research and progress in the industry indicate such revisions to be desirable.

A supplement is being prepared containing explanations and suggestions for engineers who are interested in designing systems that comply with these standards. This supplement may be secured on application to any of the organizations listed below, which are the organizations that have endorsed the standards: *American Society of Heating and Ventilating Engineers* (Illinois Chapter); *American Society of Refrigerating Engineers; Chicago Association of Consulting Engineers; Chicago Master Steam Fitters Association; Chicago Ventilating Contractors Association; Illinois Society of Architects; National Electric Manufacturers Association; Refrigerating Machinery Association; Western Society of Engineers.*

11. Design Duct Capacity: Provision may be made in the duct design for recirculation of 100 percent of the circulated air. *Note*: This is for economical heating or cooling prior to occupancy.

The inlets, outlets and ducts shall have sufficient capacity to permit the introduction of 100 percent of air from outside and its removal.

12. Design Air Distribution—shall be such that:

(a) There shall be no mechanically produced air velocity within the occupied zone exceeding 50 linear feet per minute.

(b) The difference between the temperature of air currents in the occupied zone and the average temperature of the occupied zone shall not be greater than as shown below for the various air current velocities:

Air Current Velocity Linear Feet Per Minute	Temperature Difference Average F Minus Current F
40 and over	2
Less than 40	3

(c) The temperature shall not vary more than 2 F at the same level within the occupied zone.

Note: Nothing herein shall be taken to prevent use of defiectors, diffusing grilles, nozzles and the like with comparatively high velocity air currents above the occupied zone.

13. Refrigerating Apparatus and Refrigerants: All refrigerating and cooling equipment, piping and specialties used in connection with air conditioning shall be designed and installed in accordance with the requirements of the City of Chicago, Department of Boiler Inspection and Cooling Plants, and the rules of the Chicago Board of Health.

The following are minimum acceptable capacities for various parts of the refrigerating apparatus to be used in cooling.

(a) Assumed condenser cooling water temperatures 76 F for city water and 80 F for cooling tower water.

(b) When the refrigerant is flammable, irritant or toxic, a receiver of sufficient capacity to contain the entire operating charge of refrigerant shall be provided. Under such conditions adequate valves and facilities shall be provided for storing all of the refrigerant within the receiver.

Note: Should the apparatus be required for both cooling and heating at intervals during the same season, the evaporator shall be so arranged that it is not exposed to temperatures which will cause a pressure greater than that for which the evaporator was designed.

(c) Apparatus such as evaporators, condensing units, expansion valves, etc., shall be installed with sufficient line valves and with proper fittings to permit efficient servicing or quick replacement of operating parts without exposing the interior of the refrigerant-containing parts to air and moisture where such exposure would affect the system adversely.

(d) Accessibility for servicing and repairing of all parts of the air conditioning system must be provided.

(e) A leak-detecting device approved by the Chicago Board of Health must be provided where required.

14. (a) The parts exposed to moisture shall be made of material at least equal to galvanized steel, and the gauges and weights of sheets and structural bracing shall conform with the recommendations of the *A.S.H.V.E. Guide*.

(b) Each branch of a duct system shall be provided with means for adjusting the air volume delivered.

15. Heat Transfer Apparatus:

(a) All convectors where condensation might occur when cooling shall have drain pans with tubing running to a drip with air break above a trapped sewer connection or its equivalent.

(b) No fixed spray humidifier or spray dehumidifier shall be installed above the basement of a building unless there shall have been installed under it a water tight safing graded to a drain so that in case of leakage or overflow there shall be no danger of water damage to the rooms under the apparatus.

(c) Eliminator plates shall be provided for spray humidifiers, for spray dehumidifiers and shall be made of some durable material and so designed as to be easily replaceable.

(d) Air filters shall be easily accessible for inspection and removing without danger of spilling dust to the leeward of themselves when the substitution is made.

16. Noise Control: The following increase in noise level measured in the occupied zone nearest to the source of the noise and due to operation of air conditioning apparatus shall not be exceeded:

Existing noise levels. Air Conditioning not in operation. Windows and doors closed. Occupation and Activity normal. Decibels	Resultant maximum sound levels —Air Conditioning in operation. Decibels
5	7
10	15
15	23
20	30
25	38
30	45
35	52
40	60

17. Insulation: In air conditioning work in which refrigeration is employed, all chilled surfaces exposed to temperatures and humidities which cause deposition of dew shall be insulated to such an extent at least that no condensation shall gather outside of the insulation.

18. Guarantees: Guarantees of performance when required shall be limited to capacities or conditions that are described and can be measured accurately and the guarantees shall state the condition under which such capacities or results are to obtain.

Nanking, China, Has Air Conditioned Theater

First air conditioned theater in Nanking, China, is the recently completed New Capital. The air conditioning system, which provides for the circulation of a constant volume of filtered and conditioned air with automatic regulation of temperature and humidity adjustable to both summer and winter comfort, comprises a "Freon" compressor driven by a 125 hp. motor, shell and tube type condensers, and a spray type air conditioning unit. Water is cooled for condensing purposes by a 50 ft cooling tower. Source of the water for this system is a deep well, with an auxiliary source from city mains. A 36 in. diameter multivane fan driven by a 30 hp motor, draws the air into the conditioning apparatus.

The system was planned to avoid abrupt changes in temperature, so that one entering the theater from the street, or leaving the theater after a prolonged stay within, will not experience the sudden shock of a too abrupt change. To accomplish this temperature change gradually on entering the outer ticket foyer, one passes into the second or "crush" lobby, and thence to the auditorium; graded temperatures are maintained in these spaces.

Many other modern safety devices and comfort features have been incorporated in this play-house. While the majority of the films will be shown in their English version, with dialogue in English, a smaller screen has been placed directly below the large screen, for the projection of Chinese translations of the dialogue.—*J. C. Tweedell.**

*Manager, Export Div., York Ice Machinery Corp., York, Pa.

Heating·Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers JOURNAL SECTION

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Table of Contents

Comfort Standards for Summer Air Conditioning, by F. C. Houghten and Carl Gutberlet....543
Subjective Reactions of Human Beings to Certain Outdoor Atmospheric Conditions, by C.-E. A. Winslow and L. P. Herrington....551
Nominations for 1936....557
Society to Hold 42nd Annual Meeting in Chicago....558
President's Message to Members....559
Local Chapter Reports....560
Candidates for Membership....563
Candidates Elected....564

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Pittsburgh Experiment Station of the U. S. Bureau of Mines where the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS is located

Comfort Standards for Summer Air Conditioning

By **F. C. Houghten*** ***(MEMBER)*** **and Carl Gutberlet†** ***(NON-MEMBER)***

Pittsburgh, Pa.

THE Effective Temperature Scale presented[1] to the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS by its Research Laboratory in 1923, and the subsequent development[2] of the winter and summer Comfort Zones were assumed at the time to apply universally to indoor air conditioning, regardless of daily variations in the outdoor temperature and the length of exposure of occupants to indoor conditions. In applying these findings to air conditioning in theaters and elsewhere, it soon appeared, however, that the information available was not adequate and that some consideration should be given to the temperature of the outside air. It was assumed as a result of practical applications in the air conditioning field that rigid limits had to be applied to the moisture content of the indoor air in order to avoid sensible perspiration and other undesirable effects. Consequently there has been developed, largely through box office complaints in theaters, a variable indoor summer cooling standard based upon the outdoor dry-bulb temperature, which has been used as a standard in the air conditioning chapter of the A.S.H.V.E. GUIDE since 1933. This variable standard is presented in Table 1,[3] and the range in allowable indoor cooling conditions for an outside dry-bulb temperature range from 73 F to 95 F is plotted, *A-A*, on the psychrometric chart, Fig. 2.

It will be noted that this standard allows only a single definite moisture content or dewpoint temperature of the air, regardless of outside conditions, and a definite indoor dry-bulb temperature for any given dry-bulb temperature outside. Attempts to apply this standard in practice for different air conditioning applications and with different types of equipment have resulted in considerable chaos and dissatisfaction, resulting in the resubmission of the study to the Society's Research Laboratory.

Table 1—Desirable Indoor Air Conditions in Summer Corresponding to Outdoor Temperatures[3]

(Applicable to Exposures Less Than 3 Hours)

OUTDOOR TEMP. (DEG F) DRY-BULB	INDOOR AIR CONDITIONS WITH DEW POINT CONSTANT AT 57 F		
	DRY-BULB	WET-BULB	EFFECTIVE TEMP.
95	80.0	65.0	73
90	78.0	64.5	72
85	76.5	64.0	71
80	75.0	63.5	70
75	73.5	63.0	69
70	72.0	62.5	68

[3]A.S.H.V.E. GUIDE, 1935, Chapter 2, Table 2, p. 48.

*Director, A.S.H.V.E. Research Laboratory.

†Research Asst., A.S.H.V.E. Research Laboratory.

[1]Determining Lines of Equal Comfort, by F. C. Houghten and C. P. Yagloglou. (A.S.H.V.E. TRANSACTIONS, Vol. 29, 1923, p. 163).

See also—Effective Temperature with Clothing, by C. P. Yagloglou and W. E. Miller. (A.S.H.V.E. TRANSACTIONS, Vol. 31, 1925, p. 89).

[2]Determination of the Comfort Zone with Further Verification of Effective Temperatures Within This Zone, by F. C. Houghten and C. P. Yagloglou. (A.S.H.V.E. TRANSACTIONS, Vol. 29, 1923, p. 361).

See also—The Summer Comfort Zone: Climate and Clothing, by C. P. Yagloglou and Philip Drinker. (A.S.H.V.E. TRANSACTIONS, Vol. 35, 1929, p. 269).

For presentation at the 42nd Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Chicago, Ill., January, 1936.

In making the study, five students of the University of Pittsburgh acting as subjects judged their feelings of warmth in various atmospheric conditions in the psychrometric rooms of the Research Laboratory, located in the Pittsburgh Experiment Station of the United States Bureau of Mines. While the results of the study are not entirely conclusive as regards all phases of the subject, they are particularly conclusive in demonstrating that the effective temperature of the indoor condition is of much greater importance than the moisture content of the air inside, or the dry-bulb temperature of the

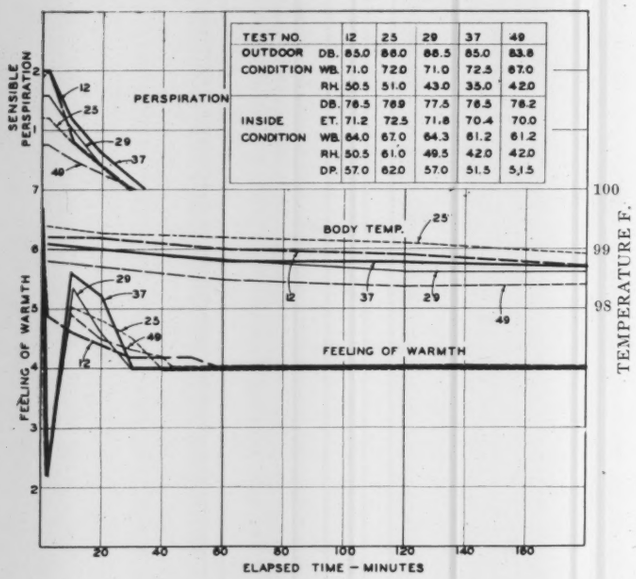
TEST NO. 12 25 29 37 49
OUTDOOR CONDITION DB. 85.0 86.0 86.5 85.0 83.8
WB. 71.0 72.0 71.0 72.5 67.0
RH. 50.5 51.0 43.0 35.0 42.0
INSIDE CONDITION DB. 76.5 76.9 77.5 76.5 76.2
ET. 71.2 72.5 71.8 70.4 70.0
WB. 64.0 67.0 64.3 61.2 61.2
RH. 50.5 61.0 49.5 42.0 42.0
DP. 57.0 62.0 57.0 51.5 51.5
SENSIBLE PERSPIRATION
PERSPIRATION
BODY TEMP.
FEELING OF WARMTH
TEMPERATURE F.
ELAPSED TIME — MINUTES

Fig. 1—Average reactions of five subjects after entering various cooled conditions with moderate relative humidity

atmosphere outside. It is shown that air conditions ranging from 70 or 71 deg to 74 or 75 deg effective temperature give a feeling of comfort, as far as warmth is concerned, over a wide range of moisture content throughout the summer months, regardless of the prevailing outside temperature on any particular day.

Test Arrangements

One of the psychrometric rooms of the Laboratory, fully described in an earlier report,[1] was arranged so as to accommodate five subjects without crowding and without their being subjected to undesirable variations in temperature, moisture content or motion of the air. Any condition desired for summer cooling between 30 and 90 per cent relative humidity could be maintained with ease. Relative humidities as low as 20 per cent could be had with greater difficulty, when it was necessary to reduce the occupancy of the room to two subjects.

Five male students between the ages of 19 and 23 years served as subjects. Examination showed them to be normal as regards their body temperature, pulse rate, respiration and other physiological reactions which might affect their temperature regulation under various atmospheric conditions. The clothing worn consisted of athletic underwear, light-weight shirt with collar attached, tie, light socks, low shoes, light-weight summer coat, and light flannel trousers. Prior to most of the tests the subjects were exposed to prevailing outside air conditions without being shaded from the sun for a period of one-half hour or more before entering the test chamber. During the latter part of this period they walked ¼ of a mile and immediately before entering they individually recorded their feeling of warmth and the degree of perspiration on their face and body. Their feeling of warmth was graded according to the following arbitrary numerical scale: (1) cold; (2) too cool for comfort; (3) comfortably cool (not particularly uncomfortable, but a condition such that if the subject had a choice he would choose a somewhat warmer condition); (4) ideally comfortable as far as the feeling of warmth is concerned; (5) comfortably warm (not particularly uncomfortable, but a condition such that if the subject had a choice he would choose a slightly lower temperature); (6) too warm for comfort; (7) too hot. Perspiration was graded according to the following arbitrary numerical scale: (0) forehead or body dry; (1) forehead or body clammy (moist but not covered with visible perspiration); (2) forehead or body damp (perspiration just visible); (3) forehead or body wet (sweat covering the surface or standing in beads or drops); (4) perspiration on the forehead runs down or perspiration on the body runs or wets through the clothing.

Immediately upon entering the psychrometric chamber, and at frequent intervals thereafter, the subjects again recorded their individual feelings of warmth and the degree of perspiration found on their body. The subjects also observed and recorded their rectal temperature, pulse rate and any other observations concerning their feeling in or reactions to the atmospheric conditions. These observations were all made and recorded by each subject without discussing them with anyone else. One observer was engaged throughout the test in maintaining desired atmospheric conditions, making a record of same, and observing any other unusual circumstances pertaining to the test.

For most tests the atmospheric conditions were chosen beforehand and maintained constant for a half hour before the subjects entered in order to have the walls in equilibrium with the atmosphere. This condition was then maintained throughout the test, which usually lasted three hours. For several tests the subjects were brought into the psychrometric chamber in which a constant air condition was maintained for a sufficient length of time for them to become in equilibrium with it, after which the atmospheric condition was changed slowly and uniformly so as to follow a predetermined path on the psychrometric chart. In these tests the rate of dry-bulb temperature change was not greater than 1 deg in 20 minutes. When time permitted, the change in the atmospheric conditions was reversed and made to return to the starting point so as to complete a cycle when plotted on the psychrometric chart. In a few of the constant condition tests the subjects entered the cooled psychrometric chamber, not from the outside, but from a second room heated to a predetermined high temperature and humidity. This was done so that in several tests with widely different atmospheric conditions in the chamber the preliminary exposure to high temperature and the resulting physiological reactions would be the same.

Test Results

During the early part of the study a number of tests were made in constant atmospheric conditions designed to give comfort in accordance with the present GUIDE standards,[3] or with moisture content at some definite percentage of relative humidity above or below this

standard. These tests proved that conditions dictated by the present GUIDE standard invariably gave comfort, but wide variations in relative humidity also resulted in comfort provided the same effective temperature was maintained. The results of five of these tests are plotted in Fig. 1. The feeling of warmth and degree of perspiration are plotted according to the scales given above. The body temperature is also given.

The observations made just prior to entering the test chamber are plotted in all cases on the zero x axis. It will be observed that invariably the subjects felt very warm before entering and were perspiring in varying degrees. Immediately upon entering the cooled chamber a cool shock was usually experienced. However, this shock was of short duration, so that recovery to a feeling of comfort or warmer than comfortable was recorded by 10 min after entering. Usually from 20 to 45 min were required for all subjects to reach a comfort feeling of (4) or comfortable. Sensible perspiration usually disappeared rapidly. In most instances a comfort feeling of (4) was experienced about the same time that sensible perspiration disappeared. The body temperature upon entering was usually close to a degree above the generally accepted normal of 98.6 F as a result of the subjects walking in the high outside temperature. Upon entering the cooled room the body temperature invariably dropped slowly and in most cases reached normal in two or three hours.

Fig. 2 shows the course followed and the reactions experienced by the subjects during the tests in which the atmospheric conditions were changed. The atmospheric conditions in the test chamber at the time of

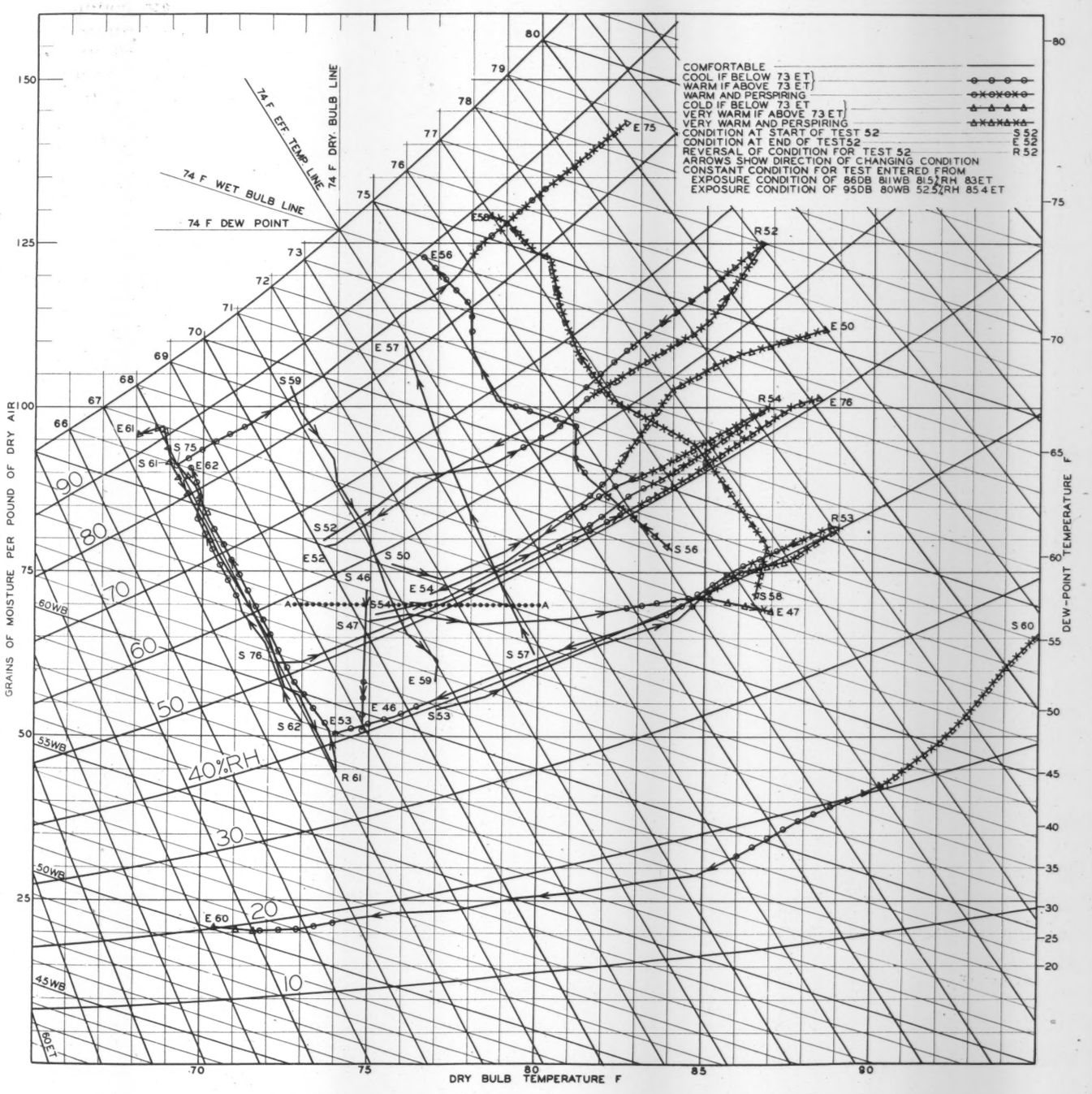
COMFORTABLE
COOL IF BELOW 73 ET
WARM IF ABOVE 73 ET
WARM AND PERSPIRING
COLD IF BELOW 73 ET
VERY WARM IF ABOVE 73 ET
VERY WARM AND PERSPIRING
CONDITION AT START OF TEST 52
CONDITION AT END OF TEST 52
REVERSAL OF CONDITION FOR TEST 52
ARROWS SHOW DIRECTION OF CHANGING CONDITION
CONSTANT CONDITION FOR TEST ENTERED FROM
EXPOSURE CONDITION OF 86DB 81WB 81.5%RH 83ET
EXPOSURE CONDITION OF 95DB 80WB 52.5%RH 85.4 ET
74 F EFF TEMP LINE
74 F DRY BULB LINE
74 F WET BULB LINE
74 F DEW POINT
GRAINS OF MOISTURE PER POUND OF DRY AIR
DEW-POINT TEMPERATURE F
DRY BULB TEMPERATURE F
60WB
55WB
50WB
45WB
40%RH
60ET

Fig. 2—Psychrometric chart showing range of effective temperatures, giving tests made with varying air conditions

entry, the range of conditions over which the subjects felt comfortable, too cool, decidedly cold, too warm and too hot, as well as the conditions during which they showed sensible perspiration, are indicated in the chart according to the key. During the first hour of these variable condition tests the atmospheric condition in the test chamber was kept constant so as to allow the subjects to become in equilibrium with it. The data obtained during this adjustment period for several tests in which all subjects became comfortable are plotted in Fig. 3.

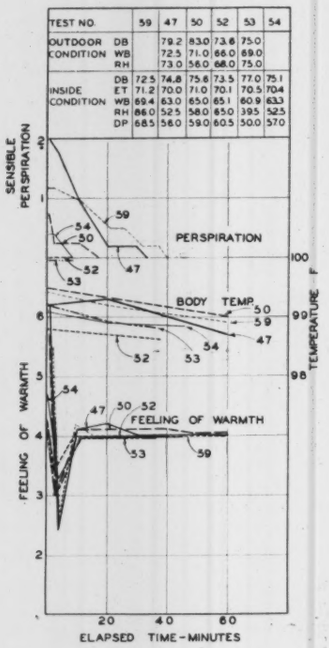

Fig. 3—Average reactions of five subjects after entering various cooled conditions with moderate relative humidity

After the approximate boundaries of the comfort zone were established by the variable air condition tests, Fig. 2, a few tests were made in various constant air conditions in the apparent comfort zone or near its boundaries, in order to determine any variation in feeling upon entering such conditions from a hot atmosphere. Two series of such tests were made. In the first series tests were made in atmospheric conditions of 76, 73, 70 and 68 deg effective temperature and 85 per cent relative humidity, and tests at approximately the same effective temperatures but with relative humidity in the neighborhood of 30 to 40 per cent. All of these tests were entered from a hot condition of 86 F dry-bulb and 81.5 per cent relative humidity, maintained with small variation in an adjoining room. Another series of four tests was made in conditions of 76 and 70 deg effective temperature with 85 per cent relative humidity, and approximately the same effective temperatures but with relative humidities in the neighborhood of 30 to 40 per cent, all entered from a condition of 95 F dry-bulb and 81 F wet-bulb maintained in an adjoining room. The results of these tests at effective temperatures of 75 to 76 deg, 73 deg, 70 and 68 deg are shown in Figs. 4, 5, 6 and 7, respectively.

The subjects showed mixed feeling of comfort and too warm or too cold in conditions near the upper or lower boundaries of the comfort zone. Tests made near the center of the zone usually showed entire agreement in the feeling of warmth of the five subjects as soon as equilibrium had been reached. In order to show these relationships the individual feelings of the five subjects in tests 69 and 73 are plotted in Figs. 8 and 9. The average values for all subjects in these two tests are plotted in Fig. 7.

A few pertinent facts concerning the 77 tests made during the summer are given in Table 2. The reactions of the subjects during the early part of the tests with changing air conditions are included. The tests are tabulated in the order of ascending effective temperatures of the air conditions. Besides the conditions of the atmosphere within the psychrometric chamber during the test, and the atmospheric condition from which the subjects entered, the table gives the feeling of warmth experienced in preliminary condition before entering the air conditioned room, the lowest degree of feeling of shock immediately following entering, the elapsed time between the time of entering the psychrometric chamber and the time when all subjects became comfortable, and whether the subjects were warm or cool during the greater part of the time between entering and the time at which they reached comfort. Column O indicates whether the condition was warm or cool for comfort. Columns P and Q give the degree of perspiration before entering the test chamber and the lapse of time after entering before sensible perspiration disappeared.

Discussion of Test Results

Inspection of the four tests made in constant conditions at 75 and 76 deg effective temperature, Fig. 4, shows that the average feeling of all the subjects never reached comfort for these effective temperatures either with low or high relative humidity. Actually, a mixed feeling of too warm and comfortable was indicated by the individual subjects in these tests. The two tests made at 85 per cent relative humidity show a greater persistence in the appearance of sensible perspiration than was the case in the low relative humidity condition. It should be noted, however, that the effective temperature was one degree higher in the 85 per cent relative humidity test.

Inspection of the variable condition tests, plotted in Fig. 2, shows a rather sharp division between reactions of comfort and too warm at about 75 deg effective temperature. Actually there is some overlapping as would be expected in data of this kind. Also there is a little tendency for the reactions felt by the subjects to lag, giving a feeling of comfort at a higher temperature when the air condition was changing to warmer, and lower when changing to lower temperatures. In no case, however, was a feeling of too warm expressed as much as one degree effective temperature below 75 deg effective temperature, or of comfort by as much as two degrees above. The varying condition tests, plotted in Fig. 2, indicate clearly that sensible perspiration appears at effective temperatures but little higher than those at which a feeling of too warm is experienced. These tests indicate a perspiration line somewhere between 76 and 78 deg effective temperature, with considerable likelihood of sensible perspiration appearing when the effective temperature is 76 deg or higher.

The constant condition tests, plotted in Fig. 1, and the variable condition tests, plotted in Fig. 2, indicate a

Table 2—Test Data from Study of Summer Cooling Standards

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Test No.	Date	Time of Entry	Inside Test Conditions					Out Door Conditions			Degree Feeling of Warmth Before Entry-Test Room	Degree of Cold Shock Upon Entry-Test Room	Elapsed Time To Comfort in Minutes	Feeling During Majority of Time Before Comfort Was Reached	Deg. of Perspiration Before Entry-Test Room	Elapsed Time Until Sensible Perspiration Disappeared—Min.
			°F ET	°F DB	°F WB	% RH	°F DP	°F DB	°F WB	% RH						
48	8-5-35	10:10 A.M.	67.9	73.8	57.5	37.0	45.5	76.0	64.0	52.5	5.6	2.5	20	WARM	0.5	15
44	7-31-35	9:58 A.M.	68.0	73.5	58.5	41.0	48.0	75.0	70.4	80.0	5.0	2.6	**	COOL	1.0	15
40	7-29-35	10:29 A.M.	68.6	73.5	60.5	47.5	52.1	74.9	67.2	69.0	6.0	3.8	20	WARM	1.4	15
43	7-30-35	1:04 P.M.	68.7	75.0	58.0	35.0	45.5	80.0	62.2	36.5	5.9	3.2	30	WARM	0.5	6
24	7-17-35	10:06 A.M.	68.8	73.8	60.6	47.1	52.0	76.0	64.5	54.0	6.0	4.8	**	COOL	1.2	12
38	7-26-35	10:04 A.M.	68.9	74.0	60.6	46.5	52.0	76.8	71.2	77.5	5.8	3.2	10	COOL	1.2	18
23	7-15-35	10:01 A.M.	69.0	74.1	60.6	46.0	52.0	77.0	67.0	60.0	5.8	2.5	20	WARM	1.0	12
45	7-31-35	1:32 P.M.	69.2	76.0	58.0	32.5	45.0	83.5	74.0	65.0	5.5	1.5	60	COOL	0.7	10
26	7-18-35	10:00 A.M.	69.2	74.7	60.8	45.0	51.8	79.0	68.8	60.0	6.0	2.8	20	WARM	2.0	25
17	7-9-35	10:00 A.M.	69.4	73.5	63.0	57.0	57.0	74.7	68.0	71.0	6.0	2.5	**	COOL	2.0	10
32	7-23-35	10:10 A.M.	69.5	74.9	60.9	45.0	52.0	79.5	72.5	73.0	6.2	2.6	30	WARM	1.4	15
28	7-19-35	10:00 A.M.	69.5	75.0	60.9	44.0	52.0	80.0	71.5	67.0	6.4	2.6	20	WARM	1.8	25
11	7-2-35	10:04 A.M.	69.7	74.0	63.1	56.0	57.0	76.5	68.0	66.0	6.0	4.0	**	COOL	1.8	25
15	7-8-35	10:15 A.M.	69.8	74.2	63.2	55.0	57.0	77.0	70.0	71.0	5.7	3.8	**	COOL	0.8	25
6	6-27-35	10:54 A.M.	69.8	73.8	63.1	57.0	57.0	76.0	68.5	69.0	6.4	5.7	40	COOL	2.3	45
31	7-22-35	1:33 P.M.	69.8	75.7	61.0	43.0	51.8	82.5	72.2	61.0	5.6	2.8	20	WARM	0.6	15
36	7-25-35	10:00 A.M.	69.9	74.3	63.1	55.0	57.0	77.5	72.5	79.0	5.2	3.0	20	WARM	1.2	15
8	6-28-35	11:32 A.M.	70.0	74.4	63.5	55.5	57.0	80.0	71.0	65.0	7.0	4.0	**	COOL	2.5	40
49	8-5-35	1:34 P.M.	70.0	76.2	61.0	42.0	51.8	83.8	67.0	42.0	6.0	2.3	44	WARM	0.8	30
21	7-12-35	10:16 A.M.	70.0	76.0	61.0	42.0	51.0	83.8	71.0	54.0	6.0	3.0	45	COOL	2.0	25
13	7-3-35	10:10 A.M.	70.0	74.6	63.2	55.0	57.0	78.0	69.0	64.0	6.0	3.0	40	COOL	2.1	30
9	7-1-35	11:04 A.M.	70.0	74.6	63.3	55.0	57.0	78.5	65.4	50.0	7.0	3.0	**	COOL	2.6	20
65	8-27-35	10:40 A.M.	70.0	76.3	60.4	40.0	50.0	86.0*	81.1	81.5	6.9	1.8	30	COOL	3.0	38
64	8-26-35	1:29 P.M.	70.0	71.4	68.2	85.0	66.6	86.0*	81.1	81.5	7.0	1.5	52	COOL	3.2	38
52	8-8-35	10:10 A.M.	70.1	73.5	65.1	65.0	65.5	73.6	68.0	68.0	4.3	3.4	10	COOL	0.0	00
18	7-10-35	1:29 P.M.	70.1	76.2	61.0	42.0	51.5	84.0	71.5	55.0	7.0	2.6	50	WARM	3.2	40
19	7-11-35	9:59 A.M.	70.2	75.0	63.5	53.5	57.0	80.0	70.0	61.5	6.0	2.5	30	WARM	1.8	25
47	8-2-35	10:04 A.M.	70.0	74.8	63.0	52.5	56.0	79.2	72.5	73.0	6.2	2.4	30	WARM	2.0	33
37	7-25-35	1:35 A.M.	70.4	76.5	61.2	42.0	51.5	85.0	72.5	55.0	6.6	2.4	30	WARM	2.0	34
54	8-12-35	10:09 A.M.	70.4	75.1	63.3	52.5	57.0				4.8	3.3	12	COOL	0.4	10
53	8-9-35	10:25 A.M.	70.5	77.0	60.9	39.5	50.0	75.0	69.0	75.0	4.3	3.0	12	COOL	0.0	00
7	6-27-35	2:54 P.M.	70.5	75.3	63.6	53.0	57.0	81.0	69.0	55.0	6.4	4.6	**	COOL	1.8	15
27	7-18-35	1:35 P.M.	70.7	77.1	61.2	40.5	51.1	87.0	72.0	48.0	6.8	1.8	20	COOL	2.2	35
30	7-22-35	10:00 A.M.	70.7	74.1	66.0	67.0	62.5	76.8	72.0	79.2	4.6	2.4	**	COOL	0.4	8
34	7-24-35	10:04 A.M.	70.9	74.4	66.0	66.0	62.0	77.8	72.5	78.0	5.1	3.1	20	WARM	1.0	15
33	7-23-35	1:28 P.M.	71.0	74.7	66.0	65.0	61.8	79.0	73.4	77.5	5.4	2.8	30	WARM	1.0	12
10	7-1-35	2:30 P.M.	71.2	76.5	64.0	50.5	57.0	85.0	65.0	34.0	6.2	5.0	80	WARM	1.6	35
12	7-2-35	1:39 P.M.	71.2	76.5	64.0	50.5	57.0	85.0	71.0	50.5	5.6	4.9	55	WARM	2.0	30
16	7-8-35	1:44 P.M.	71.2	76.5	63.9	50.0	56.6	84.6	74.0	61.5	6.5	2.2	55	WARM	1.8	40
39	7-26-35	1:30 P.M.	71.2	76.5	64.1	51.0	57.0	83.0	73.0	63.0	6.0	3.4	55	WARM	1.4	25
14	7-3-35	1:45 P.M.	71.4	76.8	64.1	50.0	57.0	86.0	71.8	50.0	6.0	4.5	40	WARM	2.1	55
22	7-12-35	2:00 P.M.	71.6	78.5	62.0	39.5	52.0	91.0	73.0	43.0	6.5	3.0	40	COOL	1.5	40
20	7-11-35	1:34 P.M.	71.8	77.4	64.3	50.0	57.0	88.0	74.2	53.0	6.8	2.6	55	WARM	2.2	20
29	7-19-35	1:30 P.M.	71.8	77.5	64.3	49.5	57.0	88.5	71.0	43.0	6.6	2.2	30	WARM	1.6	30
41	7-29-35	1:30 P.M.	71.9	75.9	66.5	61.5	62.0	83.0	68.5	48.0	6.2	4.6	50	WARM	1.8	25
35	7-24-35	1:34 P.M.	72.4	76.8	67.0	61.0	62.0	85.0	74.4	61.0	5.4	2.4	20	COOL	1.0	15
25	7-17-35	1:30 P.M.	72.5	76.9	67.0	61.0	62.0	86.0	72.0	51.0	6.0	2.6	40	WARM	1.2	30
63	8-26-35	10:35 A.M.	73.0	74.6	71.2	85.0	69.7	86.0*	81.1	81.5	7.0	1.5	52	WARM	2.6	44
66	8-27-35	1:30 P.M.	73.0	81.9	61.4	30.0	47.5	86.0*	81.1	81.5	6.8	2.1	30	WARM	3.0	32
67	8-28-35	10:25 P.M.	75.0	83.9	64.8	35.0	53.5	86.0*	81.1	81.5	6.6	2.6	**	WARM	2.7	34
74	9-3-35	1:44 P.M.	75.0	85.1	63.2	29.0	49.4	95.0*	80.0	52.5	6.9	2.9	**	WARM	3.2	40
70	8-29-35	1:40 P.M.	76.0	77.9	74.2	85.0	73.0	86.0*	81.1	81.5	6.8	3.3	**	WARM	3.0	64
72	8-30-35	1:25 P.M.	76.0	77.9	74.2	85.0	73.0	95.0*	80.0	52.5	7.0	3.3	**	WARM	3.6	52
56	8-15-35	10:24 A.M.	76.2	84.0	68.2	45.0	60.0				5.0	5.5	**	WARM	1.0	70
58	8-19-35	10:05 A.M.	77.0	86.5	67.5	37.5	57.0				4.8	6.0	**	WARM	0.2	180

* Exposure previous to entering the test chamber was in a second conditioned room.

** Feeling of comfort never reached. Column "O" indicates whether too warm or too cool.

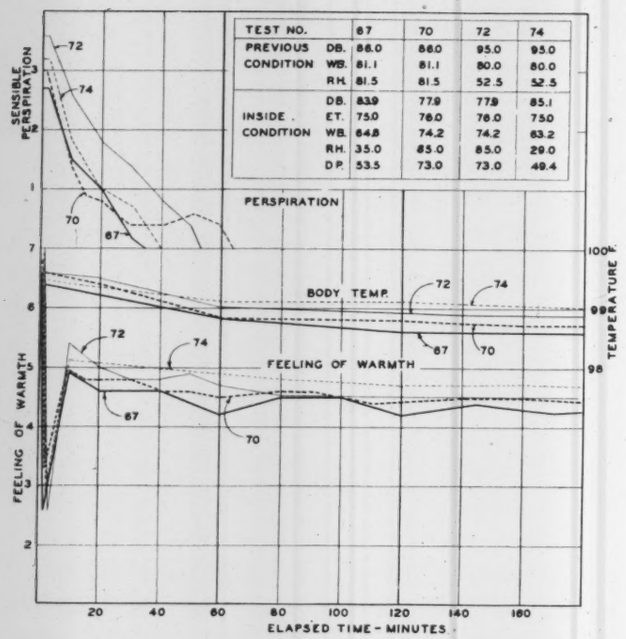
TEST NO. 67 70 72 74
PREVIOUS CONDITION DB. 86.0 86.0 95.0 95.0
WB. 81.1 81.1 80.0 80.0
RH. 81.5 81.5 52.5 52.5
INSIDE CONDITION DB. 83.9 77.9 77.9 85.1
ET. 75.0 76.0 76.0 75.0
WB. 64.8 74.2 74.2 63.2
RH. 35.0 85.0 85.0 29.0
DP. 53.5 73.0 73.0 49.4
PERSPIRATION
BODY TEMP.
FEELING OF WARMTH
SENSIBLE PERSPIRATION
TEMPERATURE F
ELAPSED TIME - MINUTES

Fig. 4—Average reactions of five subjects after entering cooled conditions of 75 E. T. and 76 E. T. with low and high relative humidity

considerable likelihood of a feeling of coolness when the effective temperature is below 70 deg. This boundary of the comfort zone is, however, not quite as sharply indicated by the tests as is the upper limit of 75 deg effective temperature. Some tests show all subjects to be comfortable at 68 deg effective temperature, while in some instances comfort was not reached even at a little above 70 deg effective temperature. There is a rather persistent tendency shown by the data for a feeling of comfort to be recorded at a lower effective temperature with low relative humidities than at high relative humidities. The study indicates that a feeling of comfort may be expected at an effective temperature 1 deg lower at about 30 or 40 per cent relative humidity than at 85 per cent relative humidity.

With very few exceptions, tests made in either con-

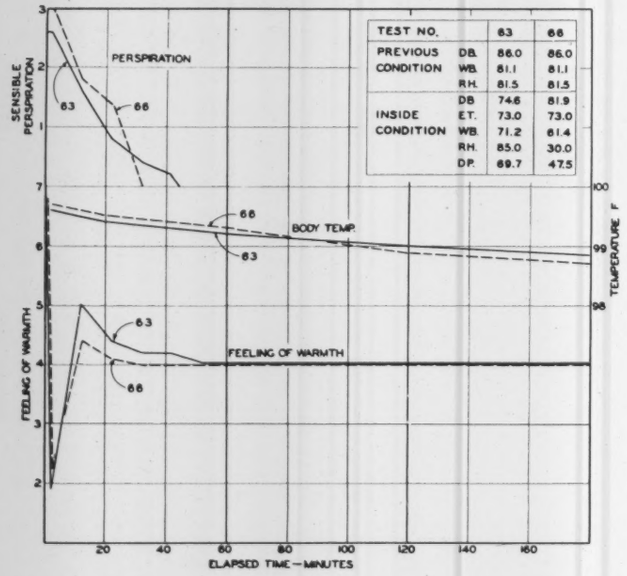

Fig. 5—Average reactions of five subjects after entering cooled conditions of 73 E. T. with high and low relative humidity

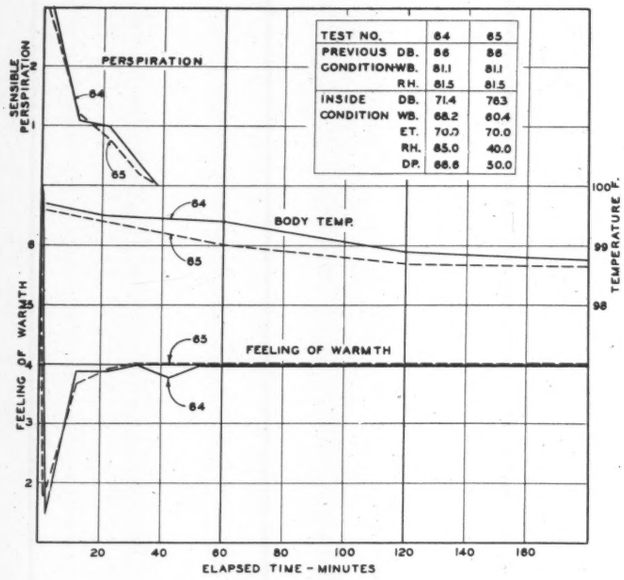

Fig. 6—Average reactions of five subjects after entering cooled conditions of 70 E. T. with high and low relative humidity

stant or varying atmospheric conditions show that the subjects quickly experienced a feeling of comfort when the effective temperature ranged from 70 to 75 deg. In most tests made in conditions within this range, and more particularly within a range of effective temperatures from 71 to 74 deg, the subjects showed complete agreement in their feeling of comfort as regards warmth. As the limits of this range on either side are approached or passed, agreement was not so certain. This is brought out in Figs. 8 and 9, which give the individual feelings of warmth of the subjects in tests 69 and 73 at an effective temperature of 68 deg. The average results for the subjects in these tests are plotted in Fig. 7.

Discussion of Observations Made During the Study

Cool Shock on Passing From a Warm to a Cooled Atmosphere:

The study shows a universal feeling of coolness upon

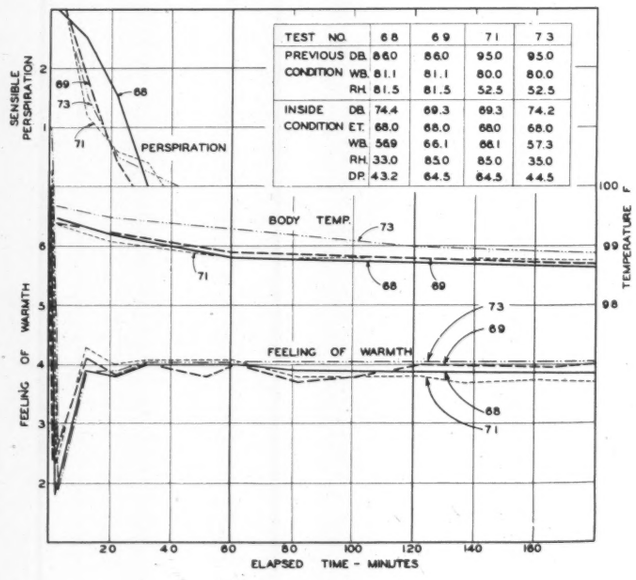
TEST NO. 68 69 71 73
PREVIOUS CONDITION DB. 86.0 86.0 95.0 95.0
WB. 81.1 81.1 80.0 80.0
RH. 81.5 81.5 52.5 52.5
INSIDE CONDITION DB. 74.4 69.3 69.3 74.2
ET. 68.0 68.0 68.0 68.0
WB. 56.9 66.1 66.1 57.3
RH. 33.0 85.0 85.0 35.0
DP. 43.2 64.5 64.5 44.5
PERSPIRATION
BODY TEMP.
FEELING OF WARMTH
SENSIBLE PERSPIRATION
TEMPERATURE F
ELAPSED TIME - MINUTES

Fig. 7—Average reactions of five subjects after entering cooled conditions of 68 E. T. with high and low relative humidity

entering a cooled atmosphere from a hot condition. Table 2 shows that this varied for the different subjects in the different tests from a sensation of too cold or (1) to one of comfort or (4). On rare occasions no shock whatever was experienced. Invariably where the shock was experienced it had disappeared within 10 min. Figs. 8 and 9 show that the individual reactions of the subjects during this period were quite variable. This shock was experienced by the subjects without discomfort. While the condition felt cool, the contrast with the hot condition was pleasing rather than uncomfortable in most instances. In this connection it should be kept in mind, however, that the subjects were all young men with strong vitality and that the contrast upon entering a cooled atmosphere might be quite different for an older person having a lower vitality. Neither the magnitude or the duration of the shock bears much relation to the atmospheric condition maintained or its contrast with the previous condition, but apparently depends upon the degree of sensible perspiration present upon entering.

The shock upon entering a cooled atmosphere from one of higher temperature is usually considered psychological rather than physical or physiological. It can, however, be easily explained on a purely physical basis. When an average sized person is in a high temperature atmosphere, say 95 F dry-bulb and 80 F wet-bulb, earlier laboratory studies[4] show that he will dissipate a total of 398 Btu of heat per hr, 52 Btu being eliminated as sensible heat by radiation and convection, and 346 Btu as latent heat of evaporation. In order to make this higher rate of evaporation possible, the body secretes perspiration at a sufficient rate to keep the body visibly wet. Under this condition evaporation is rapid; in fact, sufficiently rapid to take care of the 346 Btu of latent heat referred to. Sensible heat loss is reduced to 52 Btu by the small difference between the temperature of the surface of the body and the atmosphere. If this person suddenly passes into an atmospheric condition of 74 F dry-bulb and 64 F wet-bulb, the earlier laboratory findings[4] show that his sensible heat loss increases to 275 Btu per hr under normal conditions and latent heat decreases to 125 Btu per hr. Under the abnormal condition resulting from the sudden change, however, the body is wet with perspiration and the latent heat loss continues at the higher value of 346 Btu per hr, making a total of latent and sensible heat loss upon entering the cooled atmosphere of 621 Btu, which naturally gives a sudden cool shock. It is natural, therefore, that the cool shock upon entering a cooled atmosphere from a

[4]Heat and Moisture Losses from the Human Body and Their Relation to Air Conditioning Problems, by F. C. Houghten, W. W. Teague, W. Ed. Miller and W. P. Yant. (A.S.H.V.E. Transactions, Vol. 35, 1929, p. 245).

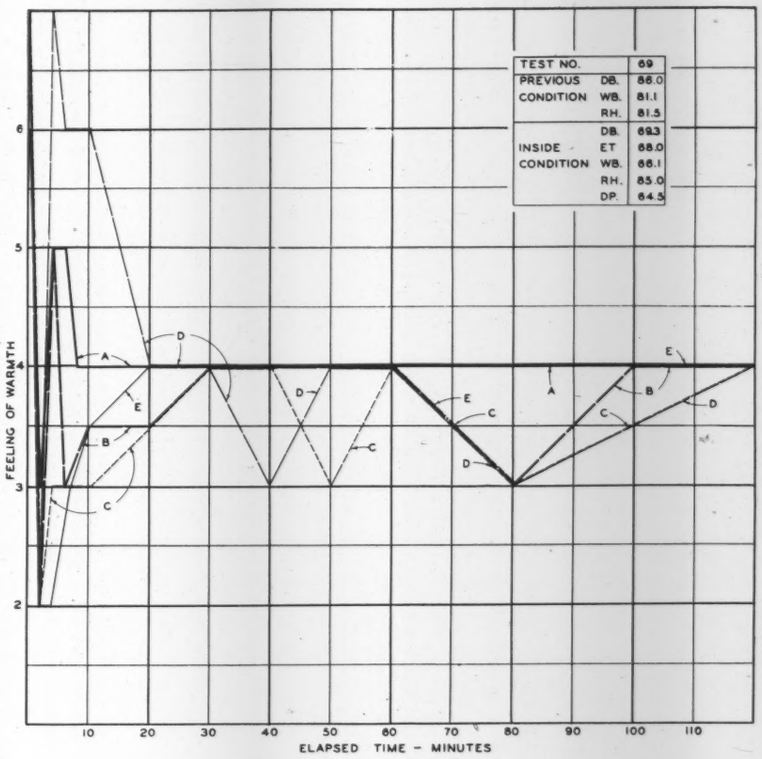

Fig. 8—Reactions of five subjects after entering a condition in which they were slightly cool for comfort

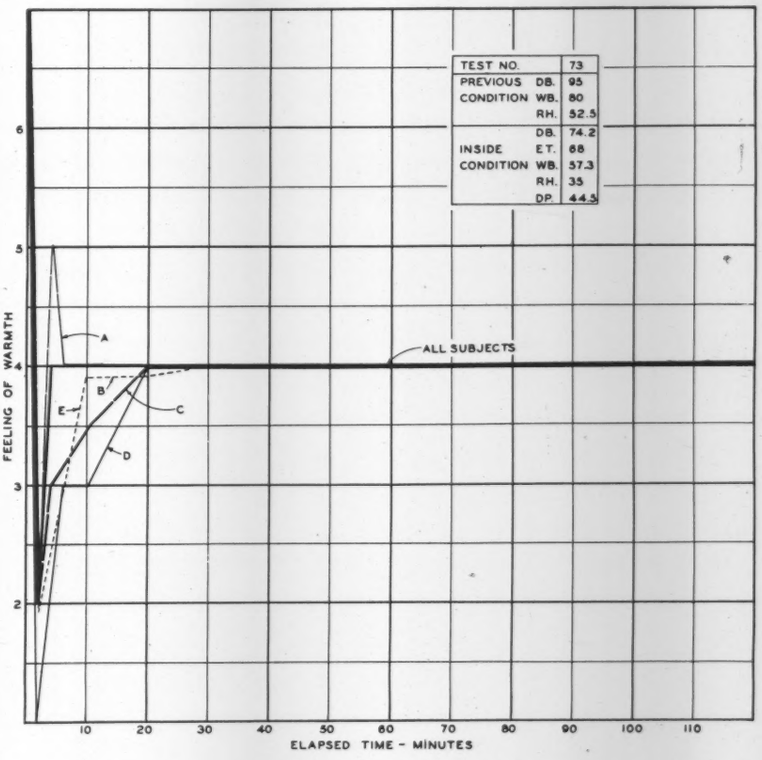

Fig. 9—Reactions of five subjects after entering a condition in which they became comfortable

hot one should depend more upon the condition of the body, including the perspiration thereon at the time of the change, than on any other factor. A study of skin temperatures during this transition would be very interesting and is recommended as a part of a continued study of this phase of the subject.

Relative Humidity Limitations:

Considerable confusion exists regarding the effect of relative humidity on the comfort of occupants of space cooled during the summer. Sufficient time was not available during the summer to make a comprehensive study of small variations in reactions to small differences in relative humidity. This phase of the study should receive further attention by the Laboratory in a continued study of the entire subject. The observations which were possible during the study of feeling of warmth indicate rather conclusively, however, that relative humidity over a considerable range is of much less importance than had been supposed. In fact, the study indicates that a person having no knowledge of atmospheric conditioning in general and of the particular conditions pertaining around him seems to have little conception of the moisture content of the air. There was a tendency for those subjects in this classification to interpret as humid any hot condition where they perspired freely. Some such reactions were recorded when the relative humidity was actually as low as 30 per cent. A person more accustomed to air conditioning seems to judge the relative humidity of the air in which he is located more by the feeling of clothing and other objects outside of his body, rather than by sensations resulting from contact between his body and the atmosphere.

If high relative humidities are to be avoided it should be on account of their effect on objects within the occupied space, rather than due to any feeling of the occupants themselves. At 85 per cent relative humidity the feeling of paper and the way it handles is greatly affected, particularly when the dry-bulb approaches or exceeds 75 F. Colored drawing pencils used by the subjects in plotting data during the tests tended to become soft and unusable, carbon paper used in the typewriter became soft and smudgy, and attempts to erase on typewritten sheets resulted in a smeared appearance.

Atmospheric conditions with relative humidities in the neighborhood of 20 per cent and around 75 deg effective temperature occasionally gave a dry burning sensation immediately after being entered, particularly when entered from a cooler condition. This sensation, however, quickly disappeared and probably resulted from lack of immediate physiological adjustment in the secretion of perspiration upon entering this condition from one where a lower rate of secretion of invisible perspiration was required. A person who does not perspire easily may have erratic sensations of warmth in these conditions. This sensation is never experienced when the conditioned space is entered from one sufficiently warm so that the body is perspiring sensibly. As a result of the study made during the past summer, it appears that no limitation need be placed on relative humidities between 30 and 60 per cent and that there is a possibility that further study may further expand these limits. Continued study of this phase of the subject is strongly recommended.

Sensations Upon Leaving a Cooled Atmosphere:

A marked reaction is always experienced upon leaving a cooled atmosphere and re-entering the outside high temperature atmosphere. The experience of those taking part in the study during the past summer indicated that this reaction is of rather short duration. The sensation seems to be one of burning heat on the surface of the body, particularly where it comes in direct contact with the atmosphere. The men acting as subjects frequently observed a particularly burning sensation of the skin on the face, hands and on the lower part of the legs. This sensation disappeared after from 5 to 20 min. It probably results from a lag in establishing perspiration at a sufficient rate to take care of the higher rate of evaporative cooling required in the warmer atmosphere where sensible cooling is reduced.

Variations in the Indoor Cooling Standard with Outdoor Temperature:

A great deal of attention has been given in recent years to variations in the dry-bulb temperature of indoor cooled conditions with variations in the daily outside temperature. The time available during the short summer period did not permit an intensive study of this phase of the subject. Such observations as were made did not, however, indicate any wide variation in comfort at any given effective temperature depending upon the outside temperature prior to the subjects entering the test chamber.

Probably of greater importance is the question of variation in the desired indoor conditions with the average daily maximum temperature throughout the summer season in any particular latitude. In this connection it is frequently assumed that because of the higher average daily maximum temperature in southern districts a higher effective temperature should be maintained indoors. Considering the fact that the comfort zone moves from a range of 63 to 70 deg effective temperature to a range of from 70 to 75 deg effective temperature for the latitude of Pittsburgh between the period of winter heating and summer cooling, it is natural to suppose that there will be a further change with more severe summer conditions. It should be observed from the data plotted in Fig. 2, however, that if the comfort zone moves much higher with more severe summer conditions the perspiration line must also move upward. Data are not available to indicate whether this is true or not. This phase of the subject should receive further study both in Pittsburgh and in some southern city where the average daily maximum summer temperature is higher.

Summary

The study indicates rather conclusively that the average person will become comfortable within from 20 to 40 min after entering any atmospheric condition within an effective temperature range of 70 or 71 deg to 74 or 75 deg. Within this range no appreciable variation was observed in the magnitude or the duration of the cooling shock with either the relative humidity of the cooled condition or the severity of the previous condition. Also, little variation in the rate of disappearance of sensible perspiration was observed for relative humidities up to 65 per cent; for relative humidities as high as 85 per cent there seem to be some increase in the length of time necessary for the complete disappearance of sensible perspiration.

Subjective Reactions of Human Beings To Certain Outdoor Atmospheric Conditions

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Sources of Basic Data

THE study here reported was primarily undertaken in the attempt to discover whether any subtle and hitherto unrecognized climatic factors might exert a demonstrable effect upon subjective reactions as to the pleasantness or unpleasantness of the outdoor atmosphere. Data on this point were supplemented by a study of daily variations in the incidence of illness. The basic data utilized may be summarized as follows:

1. Records taken at 8:00 a.m. of air temperature, temperature change from preceding day at the same hour, relative humidity, sunlight (expressed in percentage of full sunshine for the hour 8-9 a.m.), sunshine change (as compared with the same hour on the preceding day), wind movement, barometer, and barometric change (as compared with the same hour on the preceding day). These data, for all week days for the period December 1933 to February 1935, inclusive, were courteously furnished by Director Cornelius Doherty, of the United States Weather Bureau Station at New Haven.

2. Records of ions present in the air outside the John B. Pierce Laboratory in New Haven at 9:00 a.m. each morning from January 1934 to February 1935, inclusive. These data have been discussed from a physical standpoint by Gagge and Moriyama (1935)[3] with a description of the apparatus and methods used. For the purpose of the present paper the values are grouped according to sign and size of ions. We have classed as *Light Ions* those collected by the counter at a threshold of 0.07 centimeter per second; volt per centimeter. This procedure collects all the ions having a mobility above the value stated, with a considerable proportion of the large ions as well. Only one-fifth to one-half of the ions measured are actually of a mobility below 0.07 centimeter per second; volt per centimeter, but the *Light Ions* group is generally comparable with the results obtained by Yaglou and his associates (Yaglou, Benjamin and Choate, 1931; Yaglou, Brandt and Benjamin, 1933),[4] but with somewhat more large ions than he obtained. The *Total Ions* include all those with a mobility greater than 0.0006 centimeters per second; volt per centimeter.

3. For the whole period of the study we obtained from a group of volunteers in New Haven an expression of their general reaction to the outdoor weather conditions as those conditions affected them on their way to their offices in the morning. Each person willing to aid in this study was provided each week with a record form ruled with five spaces for each day of the week (except Sunday), headed respectively *Very Pleasant, Pleasant, Indifferent, Unpleasant,* and *Very Unpleasant.* They were asked to "indicate simply by a check their reactions to the weather in the proper column." Reports were obtained from 40-100 persons on a given day. On Saturdays the group occasionally dropped to 30, but the number of votes per day for the whole period averaged 80. It is desired to express special appreciation to the Security Insurance Co., The Southern New England Telephone Co., and the Department of Public Health of the Yale Medical School for their cooperation in securing these volunteers.

For the purpose of analysis we have numbered the five possible votes by decades from 10 to 50, 10 corresponding to *Very Unpleasant* and 50 to *Very Pleasant.* A high value, therefore, means a pleasurable reaction. It was very clear from examination of the figures that whatever this expression of sentiment meant, it did represent a subjective reaction which was quite definite and quite consistent within the group. In order to test this consistency the total group for a sample period of two months was divided into two sub-groups according to sex. The correlation between votes of the males and females for this period was 0.936 with a probable error of 0.012. Therefore, it is clear that a very real subjective phenomenon was being dealt with, influenced only to a minor degree by individual variations, and unaffected by sex.

4. Through the courtesy of the Southern New England Telephone Co. (Mr. Edward Dejon) records were furnished of daily absences, classified according to cause as reported by the individual, for the period December 1933-March 1935. The population covered included about 1400 employees of the Company in the New Haven area. Through the courtesy of Dr. Leonard Greenburg, Health Officer of the City of New Haven, records were provided of school absenteeism, similarly classified for the period December 1934-March 1935. This covered a school population of about 35,000.

The mean monthly averages of data as to meteorological conditions, ions and votes as to pleasurableness are summarized in Table 1.

Fundamental Meteorological Data

As a background for the studies a word should be said as to the basic meteorological conditions which prevailed in New Haven during the period of observation. The monthly mean values in Table 1 show that the winter of 1933-34 was an unusually cold one with a mean tem-

[1]Director, John B. Pierce Laboratory of Hygiene.

[2]Asst. Director, John B. Pierce Laboratory of Hygiene.

[3]Gagge, A. P., and Moriyama, I. M. 1935. The Annual and Diurnal Variations of Ions in an Urban Community. *Journal of Terrestrial Magnetism and Atmospheric Electricity, 40,* 295.

[4]Yaglou, C. P., Benjamin, L. C., and Choate, S. P. Changes in Ionic Content of Air in Occupied Rooms Ventilated by Natural and by Mechanical Methods. A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932, p. 191.

Yaglou, C. P., Brandt, A. D., and Benjamin, L. C. 1933. Observations on a Group of Subjects Before, During and After Exposure to Ionized Air. *Journal of Industrial Hygiene, 15,* 341.

For presentation at the 42nd Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Chicago, Ill., January, 1936.

Table 1—Mean Monthly Values for Basic Meteorological Data, Ion Counts, and Votes as to Pleasurableness (8-9 A. M.)

Month	Vote.	Rel. Humid- Temp. F	ity %	Sun Shine %	Wind miles per hr	Bar. mm	Ions per c.c. Light Positive	Light Negative	Total Positive	Total Negative
Dec. '33	26	26	71	27	10	762				
Jan. '34	23	27	75	22	9	763	396	224	11100	12100
Feb.	24	13	67	36	11	767	351	287	12500	13650
Mar.	21	33	71	50	10	770	287	285	11740	12180
April	21	48	73	57	9	765	303	273	8900	8930
May	22	57	70	41	7	763	391	251	6980	7530
June	22	67	71	45	8	760	516	204	4830	5040
July	22	72	73	49	7	762	542	108	6060	5080
Aug.	20	66	71	54	7	764	337	263	5720	5910
Sept.	24	59	78	23	8	760	252	143	5840	5890
Oct.	20	50	73	47	9	763	448	324	10100	12250
Nov.	25	49	80	45	10	765	366	305	11400	12290
Dec.	24	23	68	33	10	764	319	248	10880	10780
Jan. 1935	26	23	68	46	9	766	345	286	12970	13760
Feb.	23	26	72	46	9	762	307	236	11320	13550

perature of 13 F, for the whole month of February, 1934. On two days in December, 1933,[5] and on one day in February, 1934, temperatures below zero were recorded (—8 deg, —6 deg and —14 deg respectively). During February, 1934, only six days showed temperatures over 20 deg and the maximum was 34 deg. During the three months' period (December-February) temperature changes from one day to another (in both cases at 8:00 a. m.) were often marked. In December, 1933, there was one increase of 27 deg. In January there were two increases of over 20 deg (22 deg and 23 deg), and two decreases of over 20 deg (22 deg and 32 deg). In February there were three increases of over 20 deg (24 deg, 26 deg and 30 deg) and one decrease of the same magnitude (32 deg).

Relative humidity for these three months (December, 1933-February, 1934) averaged between 67 and 75 per cent and ranged from 31 per cent to 98 per cent. During the three months there were 11 values below 50 per cent and 13 values above 90 per cent. The percentage of sunshine averaged only 22 for January, 1934. Wind movement for the three months averaged 9-11 miles per hour. On one day in January and two days in February it exceeded 20 miles (21, 25 and 26 miles). Barometric changes were often considerable. One day in January there was a drop of 21 millimeters (as compared with the previous day at the same hour), and on two days in February there were increases of over 20 millimeters (22 and 25).

During the Spring the usual changes occurred, rising temperature, increasing sunshine, decrease in wind movement, but no great average change in relative humidity. Mean monthly temperature was highest in July (72 deg). The maximum for this month was 81 deg, the minimum 65 deg. Sunshine showed monthly maxima in March (50 per cent), April (57 per cent), and August (54 per cent). Wind movement for the summer months averaged 7-8 miles, with only one or two days a month over 10 miles. In July no day exceeded 11 miles. Relative humidity reached a peak in September and November (78 and 80 per cent respectively). In September only four days fell below 75 per cent.

The winter months of December, 1934-February, 1935, were much milder than the corresponding months of the previous year, particularly February.

The intercorrelations for the daily data for the period March, 1934, to February, 1935, inclusive, are summarized in Table 2. In this computation the first three months (December, 1933-February, 1934) are omitted, but separate correlations for each three-month period of the 15 months studied will be discussed later. With a basis of 300 days for computations, the probable error for various correlations is as follows:

Correlation	Probable Error
0.1-0.3	0.04
0.4-0.6	0.03
0.7	0.02
0.8-0.9	0.01

Therefore, all correlations of 0.15 or over are more than three times their probable error and may be considered statistically significant.

Ignoring for the present the votes and ions, it will be noted that temperature is negatively correlated with the barometric reading, barometric change, wind and sunshine, and is positively correlated with temperature change and relative humidity. Temperature change shows the same general relations but has a very high correlation with barometric change (—0.55). Relative humidity is positively correlated with temperature and temperature change, and negatively correlated with sunshine (—0.55), barometric change (—0.44) and sun-

Table 2—Summary of Inter-Correlations Between Daily Observations, March, 1934-February, 1935

	Vote	Temp.	Temp. Change	Rel. Hm.	Sun	Sun Change	Wind	Bar.	Bar. Change	Light Positive	Light Negative	Total Positive
Temperature	—.04											
Temp. chg.	—.18	.23										
Rel. Hum.	—.64	.24	.26									
Sunshine	.78	—.13	—.20	—.55								
Sun. chg.	.49	—.05	—.20	—.34	.64							
Wind	—.09	—.19	—.15	—.11	—.08	.02						
Barometer	—.18	—.31	—.16	—.09	.26	.07	—.11					
Bar. chg.	.41	—.18	—.55	—.44	.43	.37	.00	.34				
Lt. Ions Positive	.15	.24	—.20	—.21	.18	.10	.00	—.12	.16			
Lt. Ions Negative	.03	—.16	—.18	—.24	.13	.07	.08	.07	.22	.30		
Total Ions Positive	—.35	—.34	.16	.26	—.20	—.13	—.23	.17	—.15	—.10	.16	
Total Ions Negative	—.24	—.36	.08	.25	—.22	—.06	—.18	.15	—.01	—.10	.19	.84

Table 3—Basic Meteorological Data, Ion Counts and Comfort Votes, according to Wind Direction. Values Given Represent Mean Excess for Given Period of Land-Wind Days over Sea-Wind Days

Period	Vote	Temp. F	Rel. Humidity %	Sun shine %	Wind miles per hr	Bar. mm	Light Pos. Ions	Light Neg. Ions	Total Pos. Ions	Total Neg. Ions
Dec. '33-Feb. '34	0	—9	— 8	16	2	7	90	100	—4000	—3200
Mar.-May, '34	+3	—4	—10	19	1	5	16	72	590	350
June-Aug. '34	+5	—3	—11	19	0	2	29	38	— 900	10
Sept.-Nov. '34	+7	—5	—11	8	0	3	15	—24	—3730	—6500
Dec. '34-Feb. '35	+2	—9	—11	20	0	4	9	25	—3600	—4100

[5]To avoid repetition it should be noted that all data here cited refer to 8-9:00 a. m., and that Sundays are omitted from consideration.

shine change. Sunshine is positively correlated with barometer and barometric change, and negatively correlated with temperature change and relative humidity. Sunshine change is positively correlated with sunshine (0.64), and shows the same relations as sunshine to the other variables. Wind movement is negatively correlated with temperature and temperature change. Barometer and barometric change are positively correlated with sunshine and with each other, and both are negatively correlated with temperature, temperature change and relative humidity.

These relationships are all fairly obvious, but are merely reviewed here in relation to their mutual influences on the sensations of pleasantness and the ionic content of the air.

One other important problem of a basic nature remains to be considered; that of wind direction. In New Haven, the important factor here is the neighborhood of Long Island Sound to the South. We have classed winds from the west, north-west, north and north-east as land-winds, and all others as sea-winds. The results of this analysis are presented in Table 3 by three-month periods.

It will be noted that the figures in Table 3 are stated in terms of mean excesses of values for land-wind days over sea-wind days. It is apparent that the (northerly) land-wind days are *always cooler* and dryer and more sunny than the (southerly) sea-wind days. They were slightly more windy in Spring and had higher barometric readings. The effects on temperature were most marked in winter. The land-wind days were on the whole more comfortable except in the first winter quarter.

Light ions were very slightly higher on land-wind days. Total ions were very markedly lower for the land-wind days in fall and winter.

Ionic Content of the Atmosphere

With this general meteorological background the new data obtained may be considered with respect to ionic content.

The data in Table 2 for the year as a whole bring out certain general relationships, but the problem is, of course, greatly complicated by broad seasonal influences which it is important to distinguish from effects of day-by-day variations. In Table 4 data are therefore presented correlations between ionic content and various meteorological factors for each quarter as well as for the entire year.

It should be noted that for a single quarter (of 75 days) the probable error for various correlations is:

Correlation	Probable Error
0.1-0.2	0.08
0.3-0.4	0.07
0.5	0.06
0.6	0.05
0.7	0.04
0.8	0.03
0.9	0.01

Therefore, for a single quarter, only correlations of over 0.25 are statistically significant.

In attempting to analyze the complex relationships involved, chief stress may be placed on total ions since—as pointed out above—the group of small ions as recorded in the tables includes a very considerable and highly variable proportion of large ions. A detailed study of the actual number of small and intermediate ions is being made by determining the characteristic curves for each day's observations (which were made at four critical thresholds). A general survey of Table 4 makes it clear, however, that in general when the total ions are positively correlated with a given meteorological condition the small ions are negatively correlated with that condition, and vice versa. This is what one would expect from the findings of Wait and Torreson (1934)[6] that the number of small ions in the atmosphere is in a large degree controlled in inverse fashion by the number of large ions present. The fact that correlations between light ions and total ions do not appear in Table 4 may be explained by the mixed nature of our small-ion group and by the general tendency of factors tending to increase all classes of ions to mask the relative relationships involved.

For immediate purposes, then, the study may be limited to a consideration of total ions and also to ions of one sign since inspection of the table shows that both

[6]Wait, G. R., and Torreson, O. W. 1934. The Large-Ion and Small-Ion Content of the Atmosphere at Washington, D. C. *Journal of Terrestrial Magnetism and Atmospheric Electricity, 39,* 111.

Table 4—Correlations of Ionic Content with Various Meteorological Data by Seasons

Light Ions Positive	Temp.	Temp. Chg.	Rel. Hum.	Sun.	Sun Chg.	Wind	Bar.	Bar. Chg.	Light Ions Positive	Light Ions Negative	Total Ions+	Total Ions−
March-May	+.20	—.23	+.15	+.13	+.34	+.14	—.26	+.08		+.73	—.50	—.32
June-August	—.02	—.29	—.03	+.17	+.04	+.20	—.13	+.19		+.10	+.07	—.02
September-Nov.	—.27	—.39	—.45	+.22	+.06	+.11	—.25	+.27		+.53	+.07	+.20
December-Feb.	.00	—.44	—.03	—.02	—.03	—.19	+.05	+.08		+.55	+.33	+.30
Year	+.24	—.20	—.21	+.18	+.10	.00	—.12	+.16		+.30	—.10	—.10
Light Ions Negative												
March-May	—.20	—.36	—.60	+.69	+.33	+.30	+.03	+.39	+.73		—.30	—.42
June-August	—.16	—.01	—.12	+.11	—.04	+.07	+.05	+.21	+.10		+.37	—.15
September-Nov.	—.18	—.16	—.35	+.04	—.06	+.08	—.09	.00	+.53		+.34	+.27
December-Feb.	+.69	—.37	.00	+.75	+.13	—.20	+.13	+.31	+.85		+.31	+.33
Year	—.16	—.18	—.24	+.13	+.07	+.08	+.07	+.22	+.30		+.16	+.19
Total Ions Positive												
March-May	—.40	+.23	+.29	—.25	—.31	+.01	+.35	—.17	—.50	—.30		+.79
June-August	—.03	—.13	+.35	—.24	—.22	+.21	+.20	—.02	+.07	+.37		+.03
September-Nov.	—.20	+.33	+.11	—.15	—.27	—.40	+.01	—.26	+.07	+.34		+.86
December-Feb.	+.24	+.17	+.40	—.19	—.06	—.57	+.16	—.17	+.33	+.31		+.95
Year	—.34	+.16	+.26	+.20	—.13	—.23	+.17	—.15	—.10	+.16		+.84
Total Ions Negative												
March-May	—.41	+.24	+.25	—.65	—.19	—.13	+.24	—.21	—.32	—.42	+.79	
June-August	—.20	—.04	+.07	—.01	—.03	+.05	+.37	+.31	—.02	—.15	—.03	
September-Nov.	—.25	+.27	—.01	—.21	—.29	—.29	+.02	—.16	+.20	+.27	+.86	
December-Feb.	+.29	+.17	+.50	—.26	—.22	—.54	+.11	—.15	+.30	+.33	+.95	
Year	—.36	+.08	+.25	—.22	—.06	—.18	+.15	—.01	—.10	+.19	+.84	

Table 5—Correlation of Total Positive Ions with Various Meteorological Conditions with Other Conditions Held Constant

Correlation with	Factors Held Constant: None	Temp.	Rel. Hum.	Wind	Sunshine	Bar. Pressure
Temperature	—.34		—.43	—.40	—.39	—.31
Rel. Humidity	+.26	+.37		+.24	+.18	+.28
Wind	—.23	—.32	—.21		—.26	—.22
Sunshine	—.20	—.26	—.07	—.23		—.26
Bar. Pressure	+.17	+.07	+.20	+.15	+.24	

positive and negative total ions follow the same course. The correlation between total positive and total negative ions is between 0.79 and 0.95 for three of the four quarters, and is 0.84 for the year as a whole. In the summer quarter alone does this correlation fail. Furthermore, if one compares the quarterly correlations of the various meteorological factors with positive and negative ions respectively for the various quarters, one observes almost identical relations.

The following relationships are strikingly apparent for both positive and negative total ions:

Total ions increase

1. With decrease in atmospheric temperature (except for winter quarter).
2. With increase in relative humidity (except for negative ions in the fall quarter).
3. With decrease in sunshine.
4. With decrease in windiness (except for the summer quarter).
5. With increase in barometric reading.

In order to determine the relative significance of these five factors, partial correlations were computed which are presented in Table 5.

It is clear that the correlation with sunshine is eliminated by holding relative humidity constant while the correlation with barometric pressure disappears when temperature is held constant. There remain three other correlations which are unaffected by holding other variables constant. It may be concluded that the total ionic content of the atmosphere is highest on cool days, on days of high humidity, and on comparatively windless days; and that each of these tendencies is independent of the other two. All these phenomena are susceptible of reasonable explanation. The higher ionic content on cool days is consistent with the higher ion counts obtained in winter, and with the normal rise observed toward evening. When the air is cool the ions present tend to accumulate near the ground and furthermore, the tendency of ions to pass from the chimneys, surfaces and openings of warm buildings into the cool air would be increased. That this phenomenon did not occur in the winter quarter (see Table 4) is surprising, but the number of observations for a single quarter necessarily yields unreliable results.

The increase of ions on relatively windless days is, of course, to be expected since wind, like vertical air currents on warm days, would tend to disperse ions. Finally, the increase of ions on moist days suggests—as would be expected—that particles of moisture vapor constitute a part of the ion population of the air.

It must be remembered that all these observations were made in a crowded city street with ample opportunity for contamination with ions from chimneys and automobile exhaust. To determine how great this effect might be, check determinations were made on 16 days in October, November and December, 1934, on the top of West Rock, a hill 400 ft high and situated in reasonably open country three miles from the Laboratory. After the regular determination had been made at the Laboratory, the ion-counter was taken out to the hilltop and connected with the vacuum line operating the windshield wiper on an automobile, and a second determination was made one or two hours after the first. On 10 days the total ion count was higher at the Laboratory and on six days higher on West Rock. The averages for the 16 days were:

	Total Ions		Light Ions	
	Positive	Negative	Positive	Negative
Laboratory	7900	8450	462	338
West Rock	6290	5160	448	547

The total positive ions, as will be noted, averaged about 25 per cent higher in the city and the total negative ions over 60 per cent higher than for the hilltop outside. The data obtained are therefore significant only for the city itself and not for the region as a whole. It was, of course, correlations with sensations of pleasure in the city which were of interest and such data are obviously of importance since so large a proportion of the human race does live in cities.

Subjective Sensations as to Pleasureableness

The analysis of results of the expressions of opinion as to the pleasantness of the outdoor weather conditions each day are of interest at this point. The correlations of expression of opinion with various meteorological conditions for each of the five three-month periods studied and for the complete calendar year March, 1934, to February, 1935, inclusive, are presented in Table 6.

A general survey of the table brings out the following general relationships:

1. The weather is more likely to be pronounced pleasant in fall and winter with decreased temperature, but shows no such relation in spring and summer.
2. The judgment of pleasantness increases very markedly with decrease in relative humidity (—.64 for the year).
3. It increases still more markedly with increase of sunshine (+.78 for the year).
4. It increases with decrease in wind velocity in two of the five quarters.
5. It increases with rising barometer (the mean value for the year (+.18).
6. It increases with a decrease in total ions of either sign (—.35 for the year).

Table 6—Correlation of Various Meteorological Data with Votes as to Pleasantness of Atmospheric Conditions. By Seasons

	Temp.	Temp. Chg.	Rel. Hum.	Sun	Sun Chg.	Wind	Bar.	Bar. Chg.	Light Ions +	Light Ions —	Total Ions +	Total Ions —
Dec. '33-Feb. '34	—.12	—.27	—.29	+.51	+.28	—.32	+.06	+.39				
Mar.-May '34	—.02	—.03	—.66	+.83	+.59	—.14	+.07	+.36	+.22	+.41	—.29	—.19
June-Aug. '34	—.08	—.07	—.79	+.75	+.46	—.26	+.22	+.36	+.09	—.25	—.35	—.22
Sept.-Nov. '34	—.36	—.41	—.66	+.78	+.48	—.08	+.31	+.58	+.19	+.11	—.27	—.19
Dec. '34-Feb. '35	—.38	—.26	—.52	+.22	+.40	—.03	+.17	+.42	—.14	—.16	—.45	—.56
Mar. '34-Feb. '35	—.04	—.18	—.64	+.78	+.49	—.09	+.18	+.41	+.15	+.03	—.35	—.31

The absence of any correlation between the sensation of pleasureableness and temperature, except in the fall and winter months of 1934-35 is somewhat surprising. It is probably accounted for by the fact that votes were taken early in the morning when no extremely high temperatures occur. No doubt votes taken in the afternoon would have shown an inverse relation with temperature in summer. It is also somewhat unexpected to find that in winter cold mornings were voted more pleasant, but the correlation can presumably be explained by the bracing effect of such mornings. It seems quite evident from the picture as a whole that the human body acclimates itself (and clothes itself) in such a way that standards are rather closely adapted to the temperature to be expected at a given season. If this were not the case, there would be some correlation between the votes and temperature for the year as a whole.

A significant negative correlation with wind velocity appears in two quarters, December, 1933-February, 1934, and June-August, 1934. No obvious reason appears for this relationship and it may be due merely to chance.

It should be noted that in all the correlations so far presented, changes in temperature, sunshine and barometric pressure, have been tabulated with regard to sign—a marked rise being placed at the top of the correlation table and a marked fall from the preceding day at the bottom. To check the possibility of variability, *per se*, correlations were also computed for the mean votes as to pleasureableness with regard to these variables, irrespective of sign, and taking into account only the actual magnitude of deviation from the preceding day. The correlations obtained were —.00 for sunshine change, +.08 for barometric change, and +.03 for temperature change, none of them, of course, being statistically significant.

There remain four correlations which are consistent and reasonably high throughout the year: a positive correlation with sunshine (and incidentally with sunshine change); a negative correlation with relative humidity; a positive correlation with barometric change (and incidentally with barometric pressure); a negative correlation with total ions. Partial correlations for these four variables are presented in Table 7.

Table 7—Correlation of Mean Votes as to Pleasantness with Various Meteorological Conditions with Other Conditions Held Constant

		Factors Held Constant			
Correlation with	None	Sunshine	Rel. Hum.	Bar. Chg.	Total + Ions
Sunshine	+.78		+.67	+.73	+.77
Relative Humidity	—.64	—.40		—.56	—.61
Barometric Change	+.41	+.01	+.19		+.40
Total Positive Ions	—.35	—.32	—.25	—.32	

It appears evident that the correlation with barometric change is a secondary one since it disappears when sunshine is held constant. The other three relationships seem to be primary and independent.

It is clear that the dominant factor in the agreeableness of the weather is—as might be expected—sunshine. The zero-order correlation is about +.8 and is reduced only to about +.7 when relative humidity is held constant. The correlation with relative humidity is also a real one. Its zero-order value is —.6 which is still —.4 when sunshine is held constant. In order to make sure that this phenomenon was not conditioned by reactions to days of actual rain, correlations for the 257 days on which there was not even a trace of precipitation between 8 and 9 a. m. were re-computed. The correlations remained essentially identical with those presented in Table 7.

There remains the negative correlation with total ions which reveals an unsuspected relationship. The correlation is consistently negative, both for positive and negative ions at all seasons of the year. It is of the order of —.3 and is unaffected by holding sunshine or relative humidity or barometric change constant. It should be emphasized that this phenomenon has nothing to do with the sign of the ions and lends no support to the theory of Dessauer that positive ions are objectionable. Indeed, since total positive and total negative ions show a mutual correlation of +.8, no separate influence of the two groups of total ions could be expected. It seems clear, however, that days on which the total ion content of the air is high are judged to be unpleasant, irrespective of sunshine and relative humidity. Since the ions in city air are presumably largely made up of vapor particles from heating plants, automobile exhausts and the like, it is believed that the observed correlation is most probably due to the effect of such substances in the atmosphere. If this conclusion is justified, it gives perhaps, new evidence of the subtle influence of odor upon human welfare.

To check these conclusions from another line of approach, the average characteristics of the most satisfactory and the least satisfactory days, as indicated by the votes of the subjects were computed. There were 43 days with mean votes of 48, 49, and 50. These were averaged as the best days while 41 days with votes ranging from 12 to 23 were taken for the worst days (10 represents the lowest possible vote, 50 the highest). The major differences were as follows:

	Per cent days				
	Sunshine	on which	Relative	Total Ions	
	Per cent	rain fell[7]	Humidity	Positive	Negative
Best Days	87	0	63	7240	7740
Worst Days	0	80	92	14100	15220

The pleasant days had also a slightly higher temperature (56 deg against 50 deg), slightly less wind (8 miles per hour as against 9), and a slightly higher barometric pressure (765 as against 761). Temperature on the pleasant days varied from 35 to 76 deg and on the unpleasant days from 26 to 75 deg; wind varied on the pleasant days from 3 to 16 miles and on the unpleasant days from 3 to 21 miles per hour. The really consistent conditions were sunshine, relative humidity and ions. The pleasant days were fair (only 7 out of 43 with less than 80 per cent sunshine) and the unpleasant days were rainy. The higher ion-content of the air in this comparison may in part have been due to moisture droplets, but the results obtained by partial correlation show that high ion counts are associated with unpleasantness even when relative humidity and sunshine are held constant.

Sickness Records

Finally, the data obtained from the Southern New England Telephone Co. and the New Haven Board of Health, in regard to illnesses causing absences from

[7]Between 8 and 9 a. m. Rainy days include those on which even a trace of rain fell at this hour.

work and from school, may be considered respectively. For the telephone company records are available of absences due to respiratory diseases for the whole year from December 1933 to February 1935. For the schools similar data are available for the three months' period December 1934 to February 1935. These were classified as to the day on which absence was first recorded.

The first thing that was obvious on analysis of both sets of data, was the tremendous excess of absences recorded for Mondays. From the school data for the whole three months the mean value for Monday was 55 per cent in excess of the weekly mean. Tuesday, Wednesday, Thursday and Friday were respectively 16 per cent,

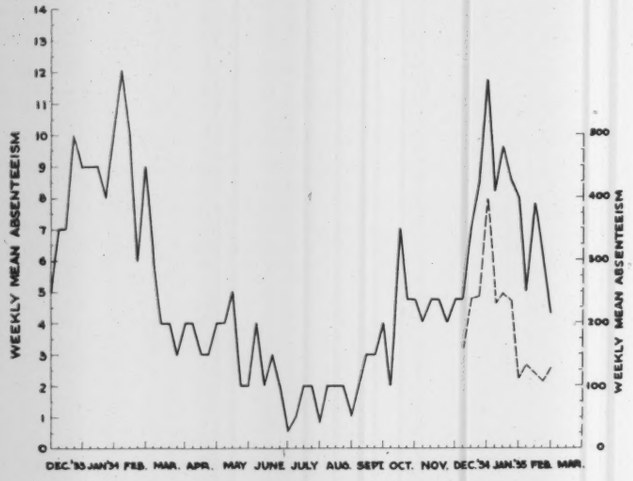

WEEKLY MEAN ABSENTEEISM
WEEKLY MEAN ABSENTEEISM
DEC. '33 JAN. '34 FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC. '34 JAN. '35 FEB. MAR.

Fig. 1—Weekly means of absenteeism

Ordinate values given on left apply to the solid curve. They refer to the telephone company employees and represent mean number of days' illness absenteeism per week for a population of 1400. Ordinate values given on right apply to the broken curve. They refer to the school children and represent mean number of days of illness absenteeism per week for a population of 35,000.

3 per cent, 33 per cent and 9 per cent below the weekly mean. This is, of course, a result of the fact that absences recorded in the school and business office as beginning on Monday include also those illnesses which really *began* to be incapacitating on Saturday and Sunday. Therefore by combining the mean weekly distribution with the actual mean value for each week a normal expectancy was computed and an attempt was made to analyze deviations from this mean expectancy with relation to various meteorological conditions for the quarter of the year. Correlations between the observed meteorological conditions on the day before and the third day before the beginning of absences were also determined. The general seasonal variations which are obvious and familiar were not of interest but all efforts to obtain, by methods of analysis, significant correlations between daily deviations from the expected mean for a given season proved unavailing. As is indicated in Fig. 1, which presents the weekly means for both school and telephone company, there are two major factors involved in the prevalence of respiratory diseases causing absences—the general seasonal swing and the epidemic curve, which culminates especially in certain particular weeks. These two factors, so far as our data are concerned, appear to mask very effectively any specific effects of the meteorological conditions on a given day. Gover, Reed and Collins (1934),[8] in a study of more accurate data (daily reports from groups of students in six cities) find that the incidence of respiratory illness is associated with low temperature, irrespective of season but particularly in early fall. High relative humidity, subnormal daily temperature range and low sunshine were also slightly correlated with high disease rate.

An analysis of the daily mortality rate for the City of New Haven with respect to various meteorological conditions was made but again without significant results except for the broad seasonal effects. Taking the year as a whole, there were correlations of +.27 with total positive ions, —.25 with temperature and +.17 with temperature change but these figures merely mean that the death-rate is higher in winter than in summer.

It is, of course, quite possible that with a larger body of data and for a longer period of time some day-by-day relationships might be apparent, but with the material at our disposal the results were entirely negligible.

Summary of Conclusions

1. The number of total ions in the air of a city street in New Haven is higher than in the adjacent countryside. It rises in winter and falls in summer. It rises with southerly (sea) winds. Total ion counts are highest in cool, moist and relatively windless days.

2. Judgment with regard to the pleasantness of outdoor atmospheric conditions, as evidenced by the vote of a group of some 80 persons taken each morning for a year, is chiefly influenced by sunshine (correlation +.8), next by relative humidity (correlation —.6), and total ions (correlation —.3). When other relevant factors are held constant, these correlations remain significant and they are apparently independent factors directly affecting the sensation of pleasureableness connected with outdoor atmospheric conditions. The influence of ions is not related to electrical charge, since positive and negative ions show identical results. The authors are inclined to explain it as the result of the effect of those gaseous products of combustion (in houses and automobiles) which make up a large proportion of the ions in a city environment.

Mechanical Catalog Issued

The 25th Annual Mechanical Catalog, Silver Anniversary Number, was published on October 1 by the *American Society of Mechanical Engineers*. This issue shows a considerable improvement over the preceding one, both in number of pages of product descriptions carried and in make-up, a new feature being introduced this year.

The catalog has three sections: 1. Catalogs of Industrial Equipment, Materials and Supplies, arranged alphabetically by names of companies, contains illustrated descriptions of the products, manufactured by the companies represented in the book. 2. Manufacturers List, an alphabetical list of firms included in the issue, giving addresses, products manufactured and a brief historical statement about the concerns presenting catalogs. 3. Classified Index to Manufacturers contains the names of 700 firms, and lists, under 4,000 classifications, thousands of items used by industry. It is also an index to the descriptions of the specific products provided by the advertisers in the catalogs that comprise this section of the book.

[8] Gover, M., Reed, L. J., and Collins, S. D. 1934. Time Distribution of Common Colds and its Relation to Corresponding Weather Conditions. *Public Health Reports, 49*, 811.

NOMINATIONS FOR 1936

The Nominating Committee appointed to select candidates for Officers of the Society for the coming year, 1936, submits the following list of nominees:

For President:

G. L. LARSON, Madison, Wis.

For First Vice-President:

D. S. BOYDEN, Boston, Mass.

For Second Vice-President:

E. H. GURNEY, Toronto, Ont., Can.

For Treasurer:

A. J. OFFNER, New York, N. Y.

For Members of the Council:

Three-Year Term

R. C. BOLSINGER, Norristown, Pa.
S. H. DOWNS, Kalamazoo, Mich.
W. L. FLEISHER, New York, N. Y.
C. M. HUMPHREYS, Pittsburgh, Pa.

Respectfully submitted,

NOMINATING COMMITTEE,
E. A. JONES, *Chairman;*
R. J. TENKONOHY, *Secretary.*

In accordance with the provisions of the Amended Constitution, as given, ballots containing the names of the above candidates will soon be sent to the membership for voting upon prior to the Annual Meeting in January.

Art. B-VIII—Section 10. The Nominating Committee shall consist of one (1) member eligible to vote designated by each Chapter, or his alternate also appointed by the Chapter. The Secretary of each Chapter shall certify to the Secretary of the Society on or before January first the names of the member and alternate selected.

The Committee shall meet at the Annual Meeting of the Society at the call of the Secretary of the Society and shall effect its own organization and elect its own Chairman. At the Semi-Annual Meeting of the Society, if possible, the Nominating Committee shall select the nominees for the ensuing year for the offices of President, First Vice-President, Second Vice-President, Treasurer, and four (4) members of the Council. In any event the names of the nominees shall be certified to the Secretary of the Society before September twentieth, with the written consent of each nominee to fill the office for which he has been selected and their names with the offices to which they have been nominated shall be published in the October issue of the JOURNAL.

Art. B-IX—Section 2. The Secretary shall prepare ballots with the names of all candidates and forward them to the members, eligible to vote, at least thirty (30) days before the date of the Annual Meeting.

Nominations for Members of Committee on Research

Although committees of the Society are usually appointed, in view of the great importance of the Committee on Research and the financial responsibility it would be called upon to assume, it has been made more representative of the entire membership of the Society by a process of *election*. The election is governed by the By-Laws for the election of officers, with the single exception that Members of the Committee on Research are nominated by the Council instead of by a Nominating Committee.

In accordance with the Regulations for the Government of the Research Laboratory, adopted at the January, 1919, Meeting, and amended January, 1933, the Council announces the nomination of the following members of the Committee for election to succeed those members whose present terms expire January, 1936:

Three-Year Term

W. A. DANIELSON, Washington, D. C.
C. E. LEWIS, Dayton, Ohio.
D. W. NELSON, Madison, Wis.
CYRIL TASKER, Toronto, Ont., Can.
C.-E. A. WINSLOW, New Haven, Conn.

The regulations governing the nomination and election of members of the Committee on Research are as follows:

ARTICLE II—ORGANIZATION

Section 1. *Committee on Research*—There shall be a standing committee known as the Committee on Research, consisting of fifteen (15) members each serving for three (3) years and five (5) retiring each year. The outgoing Chairman if serving in that capacity during the last year of his three (3) year term on the Committee shall without election become an additional member of the Committee on Research for one (1) year.

(*a*) The Council shall nominate previous to July first of each year five (5) members to fill the vacancies of those retiring at the next Annual Meeting.

(*b*) The nominations made by the Council shall be published in the October issue of the Society's JOURNAL.

(*c*) Any ten (10) members of the Society eligible to vote may present to the Secretary over their signatures, the name of one (1) or more additional nominees for the Committee on Research, provided such name or names are presented at least sixty (60) days prior to the next Annual Meeting, and such additional nominations shall be placed on the ballot opposite the nominations made by the Council.

(*d*) The election shall otherwise conform to the regulations provided for the election of officers of the Society in the Constitution, By-Laws and Rules.

(*e*) Vacancies may be filled by the Council, such persons chosen by the Council to serve until a successor is elected at the next Annual Meeting.

The loop district of Chicago

Society to Hold 42nd Annual Meeting in Chicago

COMFORT Week will be celebrated in Chicago when members of the heating, ventilating and air conditioning profession and industry gather for the 42nd Annual Meeting of the A. S. H. V. E. to be held at the Palmer House, the Mid-year Meeting of the *National Warm Air Heating and Air Conditioning Association* at the Stevens Hotel and the 4th International Heating, Ventilating and Air Conditioning Exposition at the International Amphitheatre.

The methods used for maintaining comfort under all atmospheric conditions will be strikingly demonstrated by the exhibits which will include applications for every field of endeavor which require heating, ventilating, conditioning and cooling for comfort, efficiency and health.

At the technical meetings, reports will give details of the latest research developments on such subjects as the heat transmission of concrete, sound insulation, minimum air requirements for ventilation, summer comfort standards, corrosion in steam lines, and heat transfer through finned tubing.

Illinois Chapter members will act as hosts for the 42nd Annual Meeting of the Society and the Committee on Arrangements has been organized under the direction of J. H. Milliken, President of the local chapter.

The program of entertainment and other essential functions for the meeting are being planned by sub-committees as follows: *Reception*, J. R. Vernon; *Banquet*, J. P. Fleming; *Ladies*, Mrs. J. J. Hayes; *Entertainment*, Tom Brown; *Publicity*, Charles E. Price; *Finance*, Elmer W. Rietz.

Registration will commence at the Palmer House, on January 27 at 9:30 a. m., and the entire day will be devoted to Council and Committee Meetings. Technical Sessions will be held each morning, January 28 to 30, and a joint Research Session with the *National Warm Air Heating and Air Conditioning Association* is scheduled for Wednesday afternoon, January 29, at the Stevens Hotel. The Committee on Arrangements is planning a special entertainment program and announcement of several get-together functions will be made in the official program.

Members of the Society will find that the cost of attending the 42nd Annual Meeting can be moderate, as special hotel rates are available and round trip fares at greatly reduced rates have been authorized by the railroads. It will be possible to come to Chicago from any point in the United States at a rate of one and one-third fare for the round trip. Identification certificates will be mailed to all members of the Society in advance of the meeting.

The Fourth International Heating and Ventilating Exposition, to be held in Chicago at the International Amphitheatre, during the week of January 27, 1936, is now only three months away. Reservations for exhibition space at this date point toward a new high for the 1936 show.

The beneficial effects of modern heating, ventilating, and air

Meeting headquarters—the Palmer House

conditioning installations are understood by the general public of today. The waste incurred by obsolete equipment which has been compensated for and amateurly doctored during the depression years will now be remedied. People are beginning to realize that for year 'round comfort they must have air which is heated, cleaned and humidified in winter and cooled, cleaned and dehumidified in summer.

Constantly a struggle goes on between nature and man over the balance of weather, but today the individual is master of indoor weather.

Results of a recent sample survey by *Business Week* shows that many prospective buyers of air conditioning installations are at the gate of consideration which leads to purchase decision. But the mind of the American public now sharpened by the lean years' experience, has grown sensibly wary of the pig-in-the-poke. The survey indicates that prospective buyers intend to seek advice and see all before they decide to purchase.

At the Fourth International Heating and Ventilating Exposition a wide variety of heating, ventilating and air conditioning equipment will be presented. There will be exhibits of boilers, furnaces, steam, air, and hot water heating systems, refrigeration systems, central heating and unit heating, insulation materials and precision instruments to provide regulation and control for every type of installation, whether in home, office or factory.

Visitors to the Exposition will not only find the comprehensive display of heating, ventilating and air conditioning apparatus but will also find research laboratory exhibits which will give a preview of important scientific developments that will influence the trend in future standards of comfort. The A. S. H. V. E. Laboratory and cooperating institutions are planning exhibits that will be interesting and instructive to visitors.

The setting of the 4th International Heating and Ventilating Exposition in Chicago is the new International Amphitheatre, the time is January 27-31. Like the three previous Expositions this one is under the experienced management of the International Exposition Co. and Charles F. Roth is again personally in charge.

Lobby and entrance to the Empire Room of Palmer House

PRESIDENT'S MESSAGE TO MEMBERS

OUR PART IN THE PREVENTION OF AIR POLLUTION

The American Society of Heating and Ventilating Engineers must assume leadership in the establishment of standards in those fields wherein the training and experience of its membership qualify the Society as a whole to act in an expert capacity. It is, therefore, the duty of the Society to take such action as will help in the maintenance of an atmosphere that will promote public health and welfare. At this time permit me to urge that each chapter take the steps that are needed in this organization and in the building industry to prevent unnecessary pollution of outdoor air.

The ventilation engineer uses outdoor air as a basis for his work. A definite *quality* of outdoor air is an essential to a proper indoor-air condition. No substitute for uncontaminated outside air when the temperature of the outdoor air is close to that which provides comfort has been found.

For these reasons I appeal to each chapter to consider action that will aid in minimizing the pollution of the air of your cities and recommend an outline of study as follows:

1—A study of polluted city atmosphere:
- (a) To determine the source of pollution.
- (b) To determine the character of the substances that are nuisances.

2—Endorsements and recommendations as to the best methods, systems and appliances that in a practical way will correct conditions:
- (a) By the abatement of public nuisances.
- (b) By reducing the emissions of nuisance substances from fuel combustion and industrial processes to a tolerable minimum.

In the past we have concerned ourselves more with the removal of pollution in the atmosphere than with its prevention. I am convinced that we should now apply ourselves to the task of aiding in the prevention of pollution and take our place with those organizations that are engaged in this public work. The advances made in the studies and control of sulphur compounds and other objectionable emissions from chimneys of fuel burning plants and the knowledge of the damage they cause, clearly indicate the urgent need for action in this matter.

May I solicit your efforts in fostering the program contained in this appeal?

John Lennox — President,
American Society of Heating and Ventilating Engineers.

November 1, 1935

Local Chapter Reports

New Chapters Chartered

The Council of the Society has recently approved the petitions of members in Washington, D. C., Oklahoma City, Okla., and Winnipeg, Man., Can., for charters authorizing the formation of local chapters of the A. S. H. V. E.

The Officers and Council send greetings and best wishes to these new chapters.

Washington, D. C.

October 9, 1935. A meeting of the Washington, D. C., Chapter of the A. S. H. V. E. was held at the Hotel Harrington at 6:30 p. m. for further organization. On this occasion 31 members and prospective members were present.

After dinner, the meeting was called to order by Col. W. A. Danielson, chairman pro tem., and the minutes of the previous meeting were read and approved.

R. H. Feltwell, of the Nominating Committee, reported the following nominations for officers of the Chapter for the ensuing year:

President—Lt. Col. W. A. Danielson.
Vice-President—T. H. Urdahl.
Secretary—M. D. Kiczales.
Treasurer—W. E. Kingswell.
Board of Governors—E. J. Febrey, G. S. Frankel, L. S. Ourusoff.

After discussion, the nominees presented by the Nominating Committee were elected by a rising vote to hold office until January 1, 1936.

A letter from Secy. A. V. Hutchinson regarding the charter and name of the Chapter was read by Secretary Kiczales. The matter of a suitable name for the newly organized Chapter was discussed and resulted in the selection of Washington, D. C., Chapter.

The question of chapter dues was the next item of business and it was decided that each chapter member would contribute one dollar towards the operating fund, until final action is taken on what the stipulated chapter dues shall be, this contribution from each member to be credited when such action is taken.

The matter of a regular meeting date was then brought up and, following a discussion, it was voted that chapter meetings be held on the second Wednesday of each calendar month.

It was the decision of the members that the meeting place shall be at the particular place or locality which the paper or topic of discussion for the evening warrants, such meeting place to be designated by the Program Committee.

Mr. Urdahl, chairman of the Program Committee, introduced Mr. Galloway, of the Department of Public Buildings, who offered to conduct the members and their guests through the Department of Justice Building and explain the air conditioning system.

The business meeting was closed at 9:30 p. m. and a tour of inspection was made. Through the kindness of Edgar Hoover, Mr. Tracy, a member of the staff, conducted the party through the Crime Laboratory and minutely explained finger-print methods and others used in crime detection. Mr. Galloway, aided by the superintendent of the building, showed the party through the air conditioning equipment rooms and explained the operation of the system.

Illinois

October 14, 1935. The annual meeting of Illinois Chapter was called to order by Pres. R. E. Hattis at the Hotel Sherman with an attendance of 106.

President Hattis appointed C. W. Johnson, Chairman, F. I. Raymond and E. P. Heckel, as tellers of the election of officers, and then the minutes of the May 14, 1935, meeting were read and accepted.

J. J. Hayes, acting secretary for the previous year, read a report of the Board of Governors.

As retiring treasurer, Mr. Hayes also read the financial statement and J. R. Vernon, chairman of the Auditing Committee, reported that all accounts on the treasurer's books had been found correct.

A report of the Meetings Committee was given by S. I. Rottmayer, chairman.

C. E. Price announced that the November meeting of the Chapter would be held at Milwaukee on the third Monday of the month in conjunction with the Wisconsin Chapter of the A. S. H. V. E. and he asked the members to plan to attend.

J. J. Aeberly, chairman of the Better Relations Committee, reported that the work of the committee was status-quo.

Mr. Vernon reported that there was a net loss of 10 members for the year, with a total of 25 limited memberships in force.

The applications of A. A. Thommen, P. P. Wolff and J. P. Fleming for affiliation with the Chapter were read and accepted.

A brief report on the 1935 Semi-Annual Meeting of the Society at Toronto, Ont., was given by J. H. Milliken.

Proposed amendments to the Chapter's Constitution were presented by C. W. DeLand and copies will be sent to members for their approval.

A letter from Pres. John Howatt urged all men connected with heating, ventilating and air conditioning institutions to become associated with the Society.

President Hattis then introduced Ernest Szekely, Milwaukee, Wis., who discussed Adsorbents Used in Air Conditioning. Mr. Szekely stated that in the air conditioning field there are several adsorbents in use, principally calcium chloride, lamisilite and silica-gel. The speaker described a solid adsorbent as essentially a material which has the property of condensing and adsorbing gases and liquids. Mr. Szekely mentioned that this is essentially a surface phenomenon of the solid and adsorbents are in some cases capable of condensing up to 30 per cent of their own weight.

Mr. Szekely gave a comprehensive discussion of silica-gel, the adsorbent with which he is most familiar. After the formal talk, the speaker kindly answered many questions which were brought out in the discussion. A rising vote of thanks was given to Mr. Szekely for his very interesting and informative talk.

The teller's report was presented and accepted and each of the following new officers and members of the Board of Governors was introduced by the retiring president, Mr. Hattis:

President—J. H. Milliken.
Vice-President—J. J. Hayes.
Secretary—L. S. Ries.
Treasurer—J. R. Vernon.
Board of Governors—O. W. Armspach, C. M. Baumgardner, S. I. Rottmayer.

A speech of acceptance was made by the newly elected president, Mr. Milliken, and the meeting adjourned at 10:25 p. m., according to the report of Secretary Ries.

Michigan

October 8, 1935. The first meeting of the 1935-36 season was held at the Wardell Hotel and was preceded by dinner.

Pres. A. C. Wallich called the meeting to order at 8:00 p. m. and, after a roll call of the members present, Secy. W. F. Arnoldy read correspondence from headquarters office. Approximately 60 members and guests attended.

The principal speaker of the evening was John Howatt, Chi-

cago, Ill., president of the A. S. H. V. E., who was introduced by J. R. McColl, a past president of the Society.

President Howatt addressed the meeting on Our Changing World and spoke particularly on the subject of air conditioning. He also summarized some of the Society's plans for the coming year.

Later in the evening motion pictures of Alaska were shown and the meeting adjourned at 10:15 p. m.

Western Michigan

October 7, 1935. The Western Michigan Chapter was very fortunate to have as the first speaker of the 1935-36 season Pres. John Howatt of the A. S. H. V. E., Chicago, Ill., who gave an address entitled Our Changing World. The meeting was held in the Spanish Room of the Hotel Rowe and 20 members and guests were present. President Howatt's talk was very interesting and presented many thoughts on the manner in which changes in the heating and ventilating industry are affecting other industries.

A general discussion followed President Howatt's talk and many questions were asked concerning the Chicago Standards for Certified Air Conditioning. Action was taken by the Chapter instructing Pres. P. O. Wierenga to appoint a committee to investigate the feasibility of starting action towards the adoption of a similar code for Western Michigan. The area covered by the Western Michigan Chapter includes several cities and it was felt that a number of societies and organizations would find this of vital interest and be willing to cooperate.

President Wierenga announced the personnel of chapter committees and a rising vote of thanks was given the speaker before the meeting adjourned at 10:30 p. m.

Minnesota

September 17, 1935. The first meeting of the 1935-36 season of the Minnesota Chapter was held at the Bloomington Golf Club. Dinner was served at 6:30 and later the meeting was called to order by Pres. C. E. Gausman. The minutes of the previous meeting held in Rochester, Minn., were reviewed.

H. S. Morton introduced the speaker of the evening, R. E. Saberson, St. Paul, Minn. Mr. Saberson gave an inspiring talk, from the standpoint of a layman and a sales executive in another business, on the possibilities of air conditioning. According to the speaker, the *Forgotten Man* is the consumer who has not been approached by real salesmen and sold on new ideas. Mr. Saberson expressed the opinion that air conditioning can be the entering wedge to a revival in the building industry. With a shortage of one million homes and with old dwellings becoming obsolete, it is felt that opportunities for air conditioning and the services of heating, ventilating, and air conditioning engineers are greater than ever before.

Prof. F. B. Rowley commented on Mr. Saberson's talk and confirmed the statement that engineers are often prone to overlook the sales angle of their work.

Albert Buenger made a few remarks about the forthcoming Annual Meeting of the Society to be held in Chicago in January. Because of the location and importance of this meeting, which will be held coincident with the Fourth International Heating and Ventilating Exposition, the hope was expressed that many members of the Minnesota Chapter would attend.

N. D. Adams presented a letter commending the action of the Mayor and Council of the City of Minneapolis in adopting a minimum code of requirements for heating and ventilating and expressing the interest of the chapter in this action. A motion was made and seconded that this letter be forwarded to the Mayor and Council and that it be placed in the records of the Chapter.

For those members who were not satisfied with their golf scores in Rochester last May, the Program Committee arranged a special playoff, which started at 2:30 in the afternoon. There was some discussion about the championship changing hands, but this did not materialize. Twenty-four members and guests were on hand to improve their scores and 40 attended the dinner. Among the honored guests was F. H. Gaylord.

Western New York

October 14, 1935. Pres. W. E. Voisinet presided at a dinner meeting of the Western New York Chapter held at the Touraine Hotel, Buffalo, with 108 members and guests present. Three new members were officially welcomed and it was announced that the new Chapter Constitution was being revised to conform to the Constitution and By-Laws of the A. S. H. V. E. and that it would soon be ready for submission to the Chapter members.

The monthly message from Pres. John Howatt, Chicago, Ill., was read, regarding the many advantages of Society membership. Preliminary announcement was made that the 1936 Annual Meeting paper, Comfort Standards for Summer Air Conditioning, prepared by the Society's Research Laboratory, would be the subject for discussion at the November meeting. The paper will be presented by M. C. Beman, a member of the Council of the A. S. H. V. E.

L. T. Avery, Cleveland, O., was introduced and spoke on the subject of Current Fallacies and Problems of Air Conditioning. Mr. Avery briefly outlined four phases of air conditioning: heat, humidity, air motion, and purity, and made particular reference to the apparent misuse of the term in advertising. The speaker stressed the fact that he believed it necessary for the industry to set up standards of desired indoor air conditions under definite outdoor conditions, which in his opinion should vary with localities, type and use of building, and the nature of the occupant. Reference was made to tests conducted at the A. S. H. V. E. Research Laboratory and the University of California.

In the discussion which followed the presentation of Mr. Avery's talk, L. A. Harding brought out many interesting facts and theories relative to the subject under consideration and the speaker was accorded an enthusiastic and rising vote of thanks for his splendid talk.

September 9, 1935. The Western New York Chapter inaugurated the fall program with a golf meet and dinner at Erie Downs Country Club, Ft. Erie, Ont. Thirty-two members and guests were in attendance.

Awards for golf were distributed as follows: Earl Zimmerman, Kickers' Handicap; W. E. Voisinet, low gross; D. J. Mahoney, most 5's; J. J. Landers, most 6's; B. C. Candee, most 7's; and M. C. Beman, most on 8th hole.

President Voisinet made a preliminary announcement regarding the October dinner and meeting.

Ontario

October 7, 1935. Ontario Chapter opened the fall season with a meeting at the Weston Golf and Country Club. Twenty members participated in golf in the afternoon and at 6:30 p. m. dinner was served to 41 members and guests who were present.

Pres. M. W. Shears called upon Thomas McDonald to present the golf prizes and then introduced E. R. Gauley, who gave a coffee talk on Scale Buoys. H. H. Angus extended a vote of thanks to Mr. Gauley on behalf of the Chapter for his splendid address.

Secy. H. R. Roth was then asked to read the minutes of the preceding meeting, which were accepted as read.

The committees appointed for the coming year by President Shears were announced by Secretary Roth as listed in the Annual Report of Ontario Chapter (see Oct., 1935, Journal).

Pres. John Howatt's letter to Chapters on the Value of Membership was read to the meeting.

Announcement was made that the University of Toronto award for the best thesis on Heating, Ventilating and Air Conditioning for 1935 had been made to H. G. Hill, Toronto, Ont.

A motion was made by W. R. Blackhall that the University of Toronto award be extended during the year 1935-1936; the amount of the prize to be $25.00; and the prize to be open to

any student in the University writing on a subject dealing with Heating, Ventilating, or Air Conditioning. It was Mr. Blackhall's desire that this prize be awarded only on the basis that at least five theses are submitted in competition. The Ontario Chapter, acting with the faculty of the University of Toronto, are to be the judges in making the award.

J. S. Wood moved that this motion be referred to a committee of three with Mr. Blackhall as Chairman, to be voted on at the next regular meeting.

Mr. McDonald moved that President Shears be the Ontario Chapter's representative on the A. S. H. V. E. Nominating Committee, and in the event that Mr. Shears cannot attend the Annual Meeting in January at Chicago, Ill., he is to select a representative. This motion was carried.

The report of the auditors for 1935 was read by Secretary Roth and President Shears read a letter from O. L. Maddux relative to a motion to amend the Constitution in such a way as to make constitutional the various matters brought up in the auditors' report.

A motion, amending Section 3 of Article 6 of the Ontario Constitution, was carried: that, The Secretary or the Treasurer with the President shall sign all checks, written contracts, or other financial obligations of the Chapter authorized by the Board of Governors.

President Shears then called upon E. H. Gurney, who spoke on Chapter Activities. Mr. McDonald extended a vote of thanks to Mr. Gurney for his excellent address, before the meeting adjourned.

St. Louis

October 3, 1935. The meeting of St. Louis Chapter was called to order by Pres. J. W. Cooper at Garavelli's with 30 members and guests present. The minutes of the September meeting were read and approved.

President Cooper reported on a recent meeting with Secy. A. V. Hutchinson and several Chapter members.

Secy. A. L. Walters read Pres. John Howatt's message to Chapters.

A balance on hand of $356.33 was reported by the treasurer, E. E. Carlson.

The chairman of the Program Committee outlined plans for the remainder of this year and for the special joint meeting with the Engineers Club, October 24, with W. H. Carrier, Newark, N. J., as speaker.

C. R. Davis presented the application of W. N. O'Brien for the Membership Committee and introduced the candidate.

In the absence of R. J. Tenkonohy, chairman of the Special Committee on Amendments, J. M. Foster reported. Written recommendations and proposed amendments were read and discussed and referred back to the committee for further consideration and report.

E. A. White nominated, and E. E. Carlson seconded, Paul Sodemann for the Chapter's Nominating Committee. G. W. F. Myers nominated, and D. J. Fagin seconded, E. A. White for this committee. Mr. Sodemann nominated, and Mr. Myers seconded, L. W. Moon. It was then moved, seconded and carried that the nominations be closed and that Messrs. Sodemann, White and Moon be unanimously elected. President Cooper then appointed J. M. Foster and C. E. Hartwein to also serve on the committee with Mr. Sodemann as chairman.

After a short recess, the meeting was turned over to Mr. Myers, who led an interesting illustrated discussion on Forced Hot Water Heating Systems.

After adjournment inspection was made of a model installation of such a system mounted in an auto trailer.

New York State Appoints Dr. Greenburg

On October 15 Dr. Leonard Greenburg assumed his new duties as executive director of the Division of Industrial Hygiene, State Department of Labor, with offices at 80 Center St., New York City, having resigned as health officer of New Haven, Conn.

Dr. Greenburg is recognized as an authority on industrial hygiene and his new post has assumed increased importance since the amendment of the Workmen's Compensation Law by the last Legislature. Dr. Greenburg's new work will include an immediate study of silicosis and other dust disease hazards in industry.

As a member of the United States Health Service from 1918 to 1932, he was engaged in many investigations in the varied fields of public health and has contributed widely to scientific periodicals on occupational diseases, industrial sanitation and ventilation, dust content of air and its effects on the health of the worker, lead in the atmosphere, lead and benzol poisoning and kindred subjects.

31st Annual Meeting for A. S. R. E.

The *American Society of Refrigerating Engineers* will hold its 31st Annual Meeting at the Hotel Pennsylvania, New York, December 4 to 6 and during this three-day meeting the general and technical aspects of air conditioning and various applications of equipment will be discussed as well as commercial practice in refrigeration.

One of the topics of the meeting will be a debate on Wednesday evening, December 4, between students of Stevens Institute of Technology and Polytechnic Institute of Brooklyn, on the question "Resolved that engineering should be a closed profession." This event will be broadcast from the ballroom of the Hotel Pennsylvania at 8:30 p. m.

On Thursday afternoon, the Proposed Standards for Rating and Testing Air Conditioning Equipment will be presented by Glenn Muffly, *Chairman* of the Joint Committee composed of representatives of *A. S. R. E.*, A. S. H. V. E., *R. M. A., N. E. M. A.* and *A. C. M. A.*

On Friday morning, December 6, in addition to the technical papers, the Proposed Standard for Rating and Testing Mechanical Condensing Units will be presented by L. S. Morse for the joint committee.

A. S. M. E. Meets in New York

The 56th Annual Meeting of the *American Society of Mechanical Engineers* will be held in the Engineering Societies Building, New York, December 2 to 6. Tuesday evening, December 3, has been set aside for the presentation of honors and awards and Dean Collins P. Bliss will direct the ceremonies as grand marshal in awarding the John Fritz, the *A. S. M. E.*, Warner and Melville Medals.

A technical program to appeal to varied interest has been prepared by the professional divisions and technical committees. Members will discuss not only matters of strictly engineering interest but subjects of importance in human relations and industrial management, compensation laws, occupational diseases, etc.

On Wednesday, December 4, the afternoon session will be devoted to the Fan Test Code and the speakers will be L. S. Marks on the Measurement of Air Flow in Fan Inlet and Discharge Ducts; and M. C. Stuart and W. C. Somers on the Definition of the Quantity Heads Characteristics of Fans. On Thursday the subject of Fuels will be considered.

The result of the election of *A. S. M. E.* Officers for 1936 has just been announced as follows:

President: W. L. Batt.
Vice-Presidents: Alex D. Bailey, John A. Hunter, Robert L. Sackett, William A. Shoudt.
Managers: William Lyle Dudley, Walter C. Lindemann, James W. Parker.

Members of the A. S. H. V. E. desiring to attend the *A. S. M. E.* meeting are entitled to reduced rate railroad fares and should obtain certificates at their local ticket office which will entitle them to return tickets at a rate of ⅓ of the regular one-way fare. Certificates must be validated at *A. S. M. E.* headquarters during the meeting.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 53 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by November 15, 1935, these candidates will be balloted upon by the council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
AITKEN, JAMES, Supt., Anthes Foundry, Ltd., Winnipeg, Man., Can.	C. H. Turland H. R. Eade	J. A. Wotherspoon (*Non-Member*) William Glass
ARGUE, E. J., Salesman, Anthes Foundry, Ltd., Winnipeg, Man., Can.	C. H. Turland H. R. Eade	J. A. Wotherspoon (*Non-Member*) D. G. Michie
AUGHENBAUGH, H. E., Branch Mgr., York Ice Machinery Corp., Philadelphia, Pa.	I. C. Baker G. E. Tuckerman	Benjamin Adams S. E. Plewes
BAIRD, S. A., Consulting Engr., Peoria, Ill.	G. H. Blanding J. R. Vernon	J. E. McClellan J. H. Milliken
BECKER, W. A., Sales Engr., Grinnell Co., Chicago, Ill.	J. E. McClellan L. L. Narowetz, Jr.	L. J. Pitcher C. W. De Land
BLAIR, H. A., Service Engr., Westinghouse Elec. & Mfg. Co., Springfield, Mass.	E. R. Wolfert R. E. Holmes	R. E. Cross Milton Kalischer (*Non-Member*)
BONTHRON, R. C., Supervisor, Air Cond. Dealers, Westinghouse Elec. & Mfg. Co., Philadelphia, Pa.	R. F. Hunger L. C. Davidson	J. H. Hucker P. L. Pryibil
BRIGHAM, C. M., Gen. Sales Mgr., C. A. Dunham Co., Chicago, Ill.	C. A. Dunham O. J. Prentice	John Howatt A. V. Hutchinson
BROOME, J. H., Student, New York University, New York, N. Y.	M. C. Giannini A. A. Adler	William Rosenburg I. S. Henthorn (*Non-Member*)
CAMPBELL, ROBERT, Htg. Engr., Brooklyn Gas Co., Coney Island, N. Y. (*Advancement*).	J. E. Setchell (*A.S.M.E.*) R. B. Dale (*A.S.M.E.*)	J. W. Hunter (*A.S.M.E.*) J. E. Godsoe (*Non-Member*)
CASSELL, W. L., Consulting Engr., Kansas City, Mo.	C. A. Weiss Carl Clegg	David Caleb F. A. Sheppard
CLERICUZIO, G. P., Bloomfield, N. J.	M. C. Giannini Frederick Northrup (*Non-Member*)	J. R. Matullo (*Non-Member*) C. E. Gus (*Non-Member*)
COCHRAN, C. C., Branch Mgr., Minneapolis-Honeywell Reg. Co., Milwaukee, Wis.	C. H. Randolph J. S. Jung	F. G. Weimer W. H. Wilson
CONSTANT, E. S., Design Engr., Oklahoma Gas & Elec Co., Oklahoma City, Okla.	E. W. Gray B. R. Miller	Louin Tiller R. G. Dolan
DONOHOE, J. B., Engr. & Estimator, B. F. Donohoe Co., Boston, Mass.	D. Abrahams (*Non-Member*) D. J. Sullivan (*Non-Member*)	H. T. Hodgdon David McSwain (*Non-Member*)
ESKIN, S. G., Graduate Student, Massachusetts Institute of Tech., Boston, Mass.	James Holt E. R. Schwaz (*Non-Member*)	J. H. Zimmerman (*Non-Member*) G. W. Swett (*Non-Member*)
FERGESTAD, MARVIN, Sales Engr., The Insulite Co., Minneapolis, Minn.	H. E. Gerrish F. B. Rowley	A. B. Algren H. F. Dever
GINN, T. M., Estimator & Engr., T. M. Ginn Co., Great Falls, Mont.	H. M. Saubert (*Non-Member*) Ed Henen (*Non-Member*)	T. W. Torr S. C. Swartz (*Non-Member*)
GREGG, S. H., Pres., Shellenberger-Gregg Co., Milwaukee, Wis.	C. H. Randolph F. G. Weimer	J. S. Jung A. M. Wagner
HANCE, W. W., Draftsman, E. I. DuPont de Nemours Co., Wilmington, Del.	M. E. Kershaw A. E. Vroome	L. C. Davidson R. F. Hunger
HOPPE, A. A., Design Engr., Carrier Engineering Corp., Oklahoma City, Okla.	S. L. Rolland E. W. Gray	W. A. Russell E. F. Dawson
HUGHES, F. S., JR., Sales Mgr., Hardin Sash & Door Co., Fort Worth, Texas.	H. K. Kibbie (*Non-Member*) H. V. Kibbie (*Non-Member*)	J. V. Russell (*Non-Member*) C. C. McNutt (*Non-Member*)
HUGHEY, T. M., Sales Engr., Westerlin & Campbell Co., Milwaukee, Wis.	C. H. Randolph Ernest Szekely	J. H. Volk W. H. Wilson
KARLSTEEN, G. H., Plant Engr., Dunlop Tire & Rubber Corp., Buffalo, N. Y.	H. E. Eeden (*A.C.S.*) R. E. Olson (*R.I.S.*)	J. S. Henderson (*A.I.E.E.*) H. M. Sharp (*A.S.M.E.*)
KINGSWELL, W. E., Pres., W. E. Kingswell, Inc., Washington, D. C.	T. H. Urdahl W. A. Danielson	Leon Ourusoff E. J. Febrey
LEVERANCE, H. J., Sales Engr., J. M. O'Connor Co., Oklahoma City, Okla.	S. L. Rolland E. W. Gray	W. A. Russell F. X. Loeffler
LINCOLN, R. L., Research Engr., Hoffman Specialty Co., Waterbury, Conn.	W. K. Simpson C. P. Yaglou	C. V. Haynes F. C. Houghten
LIVAR, A. P., Mgr., Mech. Equip. Div., Reynolds Corp., New York, N. Y.	H. W. Fiedler J. O. Lennon	C. W. Stewart C. A. Fuller (*Non-Member*)

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
LOCKE, R. A., Mgr., Steel Heating Boiler Inst., Middletown, Pa.	G. E. Olsen	J. A. Darts
	H. L. Hosking	Homer Addams
MACMILLAN, A. R., Air Cond. Div., Frigidaire Corp., Dayton, Ohio.	C. E. Lewis	J. J. La Salvia
MCCLINTOCK, WILLIAM, Engr., New York, N. Y.	I. B. Helburn	H. E. Sproull
	F. E. W. Beebe	A. O. Blackman
MCLEAN, J. E., Supt. of Bldgs., University of Pittsburgh, Pittsburgh, Pa.	D. J. Purinton	L. L. Munier
	L. B. Pittock	G. S. McEllroy (*Non-Member*)
MCLOUTH, B. F., Chief Engr., Dail Steel Products Co., Lansing, Mich.	F. A. Gunther	P. A. Edwards
	J. H. Van Alsburg	C. R. McConner
MEHL, O. H., Engr., Carrier Engrg. Corp., Chicago, Ill.	S. H. Downs	W. G. Schlichting
	R. E. Cherne	J. I. Lyle
MENDEN, P. J., Sales Engr., Young Radiator Co., Racine, Wis.	T. M. Cunningham	E. T. Murphy
	M. F. May	W. F. Schleck (*Non-Member*)
MILLER, R. E., Sales Engr., American Radiator Co., Detroit, Mich.	N. A. Thomas	Ernst Wetzel (*Non-Member*)
	W. W. Timmis	W. K. Walker
O'BRIEN, W. N., Sec.-Treas., O'Brien Equipment Co., St. Louis, Mo.	F. B. Campbell	W. R. Zuhlke
	Paul Sodemann	J. M. Foster
PERINA, A. E., Staten Island, N. Y. (*Advancement*)	E. E. Carlson	G. W. F. Myers
	T. F. Rockwell	F. C. Houghten
PIKE, WALLACE, Engrg. Designer, Ternstedt Mfg. Co., Detroit, Mich.	C. M. Humphreys	F. A. Gunther
	A. R. Trevena (*Non-Member*)	H. E. Paetz
REIK, R. C., Engr., L. E. Stevens Co., Cincinnati, Ohio.	A. P. Darlington	J. W. Brennan
	W. R. Stevens	G. B. Houliston
RICKNER, C. A., Sales Engr., Kelvinator Corp., Detroit, Mich.	H. A. Pillen	K. A. Wright
	C. L. Toonder	Roy Conrad
ROBINSON, G. L., Draftsman, E. I. DuPont de Nemours Co., Wilmington, Del.	H. F. Hutzel	W. H. Cassel (*Non-Member*)
	M. G. Kershaw	A. E. Vroome
RUFF, A. G., Engr., U. S. Playing Card Co., Norwood, Ohio.	L. C. Davidson	R. F. Hunger
	J. J. Braun	F. D. Mensing
SCHECHTER, J. P., Engr., Domestic Air Cond. Co., Detroit, Mich.	K. A. Wright	I. B. Helburn
	L. V. Larsen (*Non-Member*)	G. W. Akers
SMITH, L. E., Asst. Mgr., Tech. Dept., Frigidaire Corp., Dayton, Ohio.	F. J. Linsenmeyer	F. R. Bishop
	C. E. Lewis	H. E. Sproull
SPENCE, R. T., Engrg. Mgr., Pflugradt Co., West Allis, Wis.	I. B. Helburn	A. V. Hutchinson
	C. H. Randolph	Martin Erickson
STACK, A. E., Lab. Supervisor, Washington Gas Light Co., Silver Spring, Md.	J. H. Volk	Ernest Szekely
	L. Ourusoff	W. E. Kingswell
STEWART, D. J., Mgr., Elec. Div., Barber-Colman Co., Rockford, Ill. (*Advancement*).	E. V. Fineran	R. H. Feltwell
	C. J. Braatz	D. W. Nelson
STUART, M. C., Prof. of Mech. Engrg., Lehigh University, Bethlehem, Pa.	G. L. Larson	R. P. Dewey
	W. H. Carrier	A. P. Kratz
WALSH, E. R., JR., Mgr. Retail Sales, Gilbert & Barker Mfg. Co., Springfield, Mass.	A. C. Willard	S. H. Downs
	J. F. McIntire	W. G. Boales
WILLIAMS, C. R., Draftsman, E. I. DuPont de Nemours Co., Wilmington, Del.	E. N. McDonnell	R. E. Moore
	M. G. Kershaw	A. E. Vroome
WILSON, ANDREW, Estimator, Montgomery Ward Co., Jamaica, L. I., N. Y.	L. C. Davidson	R. F. Hunger
	C. B. Pinto (*Non-Member*)	H. L. Bernstein (*Non-Member*)
	J. B. Brown (*Non-Member*)	Herman Ahlrich (*Non-Member*)
WILTBERGER, C. F., Mech. Engr., Stewart A. Jellett Co., Philadelphia, Pa.	P. L. Pryibil	J. H. Hucker
	Benjamin Adams	H. H. Erickson

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

CHAPIN, H. G., Air Cond. Engr., York Ice Machinery Corp., York, Pa.

EADE, H. R., Archt., Winnipeg, Man., Can.

ENGLISH, HARROLD, Pres., English & Lauer, Inc., Los Angeles, Calif. (*Reinstatement*).

GOTSCHALL, H. C., Instructor, New Lane Tech. High School, Chicago, Ill.

HERING, ALFRED, Htg. Contractor, Hering Htg. Co., Inc., New York, N. Y.

LAUER, H. B., Vice-Pres., English & Lauer, Inc., Los Angeles, Calif. (*Reinstatement*).

MAHON, MISS B. B., Principal, International Correspondence Schools, Scranton, Pa.

MILLER, B. R., Design Engr., Renz Engrg. & Equip. Co., Oklahoma City, Okla. (*Advancement*).

PULLEN, R. R., Asst. Master Mech., Homestake Mining Co., Lead, S. D. (*Advancement*).

RYAN, J. D., Bldg. Mgr. and Engr., Whitney National Bank Bldg., New Orleans, La.

TAYLOR, R. F., Consulting Engr., Dallas, Texas (*Reinstatement*).

ASSOCIATES

BANNON, L. E., Archt., Paterson, N. J.

JONES, N. R., Sales Mgr., Orr & Sembower, Inc., Reading, Pa.

RUEGER, C. A., JR., Sales, American Radiator Corp., Winston-Salem, N. C.

VANDERLIP, P. J., Sales & Engrg., Oil Heating Co., Lansing, Mich.

WATSON, H. D., Branch Mgr., Linde Canadian Refrigeration Co., Winnipeg, Man., Can.

YOUNG, E. O., Pres.-Treas., The Young Vtg. Co., Cleveland, Ohio.

JUNIORS

BAKER, H. L., JR., Sales Engr., American Blower Corp., New York, N. Y.

HARTIN, W. R., JR., Htg. Engr., Columbia, S. C.

HAUS, I. J., Commercial Engr., Morley-Murphy Co., Milwaukee, Wis.

LUND, C. E., Lab. Asst., University of Minnesota, Minneapolis, Minn. (*Advancement*).

MACRAE, R. B., Air Cond. Engr., E. J. Nell Co., Manila, P. I.

STUDENTS

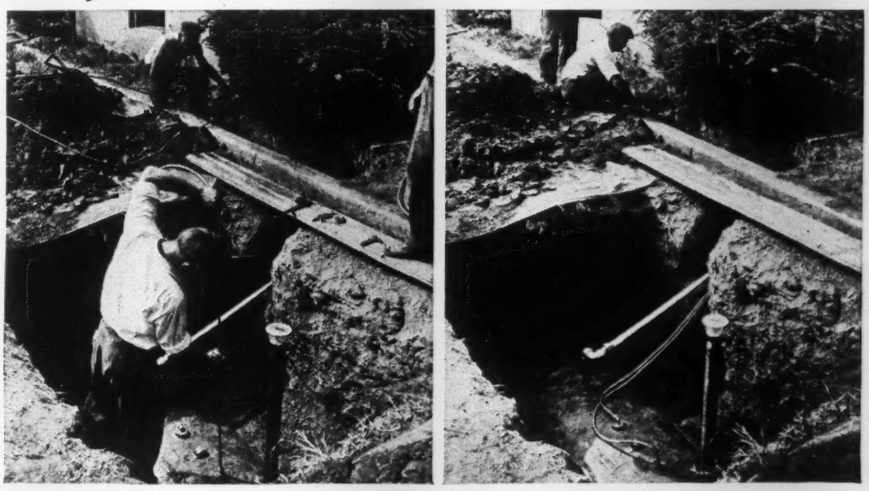
GILES, J. C., Student, University of Oklahoma, Norman, Okla.

REVERE COPPER WATER TUBE

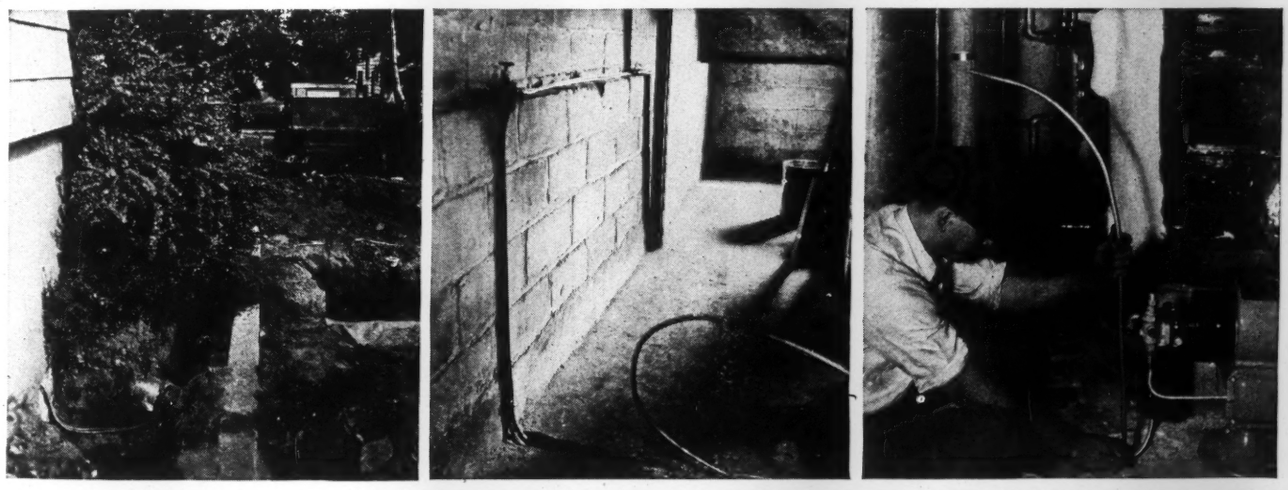
The whole story in 11 WORDS and 5 PICTURES

NON-RUSTING
LONG LENGTHS
FLEXIBLE
NO THREADING
LEAK-PROOF
FREE-FLOWING
APPROVED
QUICKLY AVAILABLE

A series of pictures, borrowed from an oil burner installation, which carry a story for plumbing pipe as well.



"Once it's down, it's down for good"



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Hundreds Sought! Hundreds Failed! Now . . .

TRUE METALLIC HOT WATER SOLDER

discovered

CHEMIST FINDS NATURE'S SECRET AFTER YEARS OF EXPERIMENTING IN A BASEMENT LABORATORY—NOT 30 FEET FROM A HEATING BOILER

For years, the need has been recognized for a substance that would stop a hot water leak by floating in the water, and lodging at the crack to harden when exposed to air. Eggs, oatmeal, ginger and *even washday water, saved and poured in at intervals*—all these were tried and many other crude attempts were made to discover the secret of a permanent repair that could be easily applied.

Many times the "discovery" was announced, only to result in disappointment—the repairs were merely temporary plugs.

It was M. Etherton of Kansas City who, experimenting in a laboratory fitted up in his basement, combined his knowledge of chemistry and metallurgy, and one fine day found in his test tube a synthetic solder that was metallic and would function at 180°F.—DOLE SODRIN. As the new substance was perfected its action in water was found to be the same as that of solder under the heat of a soldering iron.

For more than three years now tests have been made on over sixty regular commercial boiler repair jobs. The cracks sealed with Dole Sodrin are still holding up—they have every evidence of permanence. This and many other precautions were taken before any attempt was made to put Dole Sodrin on the market.

Dole Sodrin is the climax of many years of search. It is a discovery far too valuable to withhold. We offer the steamfitters a means of quoting on a new type of repair for cracks in steam and hot water cast iron boilers. We give an opportunity to get repair jobs at a price the customer can afford to pay.

And that's why we are in the boiler repair field with Dole Sodrin. We repeat it's a great discovery and a new profit-maker for our friends in the plumbing and heating industry. You will find it packaged as illustrated and marketed under our money-back guarantee. Order today from your jobber.

THE DOLE VALVE COMPANY
1901-1933 Carroll Ave., Chicago, Illinois

DOLE SODRIN

Easy, Permanent Repair for Cracks in Steam or Hot Water Cast Iron Boilers

Patent No. 1908700 Copyright, 1935—The Dole Valve Company

Equipment Developments

For your convenience in obtaining more information about any of this equipment, see coupon on page 107 . . . Add the new products and companies listed here to your Directory Section which you received in your January 1935 HEATING, PIPING AND AIR CONDITIONING and thus keep your records of sources of supply up to date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed.

Air Conditioners Use Absorption Principle

No. 600**—New "Air-O-Matic" air conditioning units for year 'round service, development of which was announced last month, operate on absorption refrigeration principle. For heating, low pressure steam is supplied to a copper finned heating coil within the central air distributing unit, can be supplemented by direct radiation if desired. This same low pressure steam, through an especially developed absorption refrigeration unit, provides refrigeration for summer conditioning. Change from winter to summer operation is effected by means of a master control.

Both the solvent and refrigerant used are newly developed chemicals and are essentially non-toxic, non-inflammable, non-corrosive to the common metals and chemically stable under all operating conditions, states the maker. The steam requirements for one ton of refrigeration are 19 lb (18,200 Btu's) per hr at 10 to 12 lb gauge pressure. Electrical requirements for one ton of refrigeration are 75 to 100 watt hours per hr. Single phase current may therefore be used in the smaller installations. For all sizes any low pressure steam boiler of proper capacity may serve.

Only metal to metal contact of moving parts within the refrigeration unit is between the seal face and seal seat of the solution circulating pump, which seal face operates in a bath of oil. Maximum pressure against seal face is 45 lb. In normal operation, pressure on the low side of the unit is between 8 and 2 in. of vacuum and the pressure on the high side is between 22 and 28 lb gauge.

Heat dissipated from refrigeration unit is 465 Btu's per min per ton. Units are rated on basis of a 40 F saturated refrigerant temperature in the cooling coil with a water temperature entering the absorber of 85 F and a water temperature leaving the condenser of 95 F. A 5 F decrease in water temperature increases the capacity 11 per cent and a 5 F increase in water temperature decreases the capacity 9 per cent. An increase of 5 F in the temperature of the saturated refrigerant in the cooling coil increases the capacity 10 per cent. Independent of the change in capacity of the unit due to change in cooling water temperature or saturated refrigerant temperature in the cooling coil, the steam requirements are 19 lb per hr per ton.

These absorption refrigeration units are compact, the 4 ton unit being 48 in. long, 19 in. wide, and 65 in. high, and the 20 ton 70 in. long, 69 in. wide and 60 in. high. Seven different sizes ranging from 4 to 35 tons are available.—Williams Oil-O-Matic Heating Corp., Bloomington, Ill.

Automatic Temperature Control for Large Buildings

No. 601—New "Graduator" system of automatic temperature control for large buildings involves a number of features of interest. To avoid over-heating in mild weather, two thermostats —one inside, the other outside, the building—so actuate the main steam supply valve as to proportion the quantity of steam fed to the system accurately to the building heat loss. At the same time, automatic graduators at the inlet to each radiator assure rapid and uniform steam distribution throughout the system.

Burnham Boilers

Have you SEEN and Studied that REPORT?

That down-to-brass-tacks report on office building operating costs all over the country. The one called "Office Building Exchange Report."

Take heating costs for instance. It shows a cost variance of from two to thirteen cents a square foot per year.

You may at once say: "Oh well, that doesn't mean a thing because there is such a variance of temperatures all over the country."

But you are wrong. It does mean something. It does, because this cost variance is based on the Atlantic Seaboard zone, north of Wilmington, Delaware.

In one of the buildings having 138,000 square feet, the heating cost is 9 cents. The boiler is an old steel one. The radiators old timers, even older than the more efficient tube-type. The air valves are all over 10 years old. The gross yearly heating cost is now $12,420.

Suppose by modernizing the heating it would cut costs 2 cents a foot, which is conservative to say the least. It would mean a saving of $2,760 a year. In five years that means $13,800. It is easy to see that such a modernization expenditure would be *self-liquidating*.

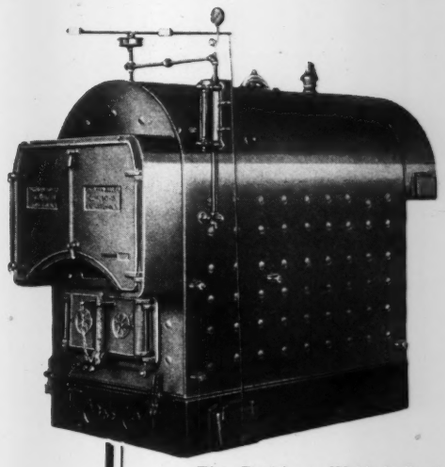
Under new Federal Housing plan, low-cost loans can be raised up to $50,000 for modernizing heating plants. We will be glad to cooperate with you in obtaining such loans.

This typical building points to you the market there is ready to be cracked open by you men who can talk with paper and pencil. Talk with comparative cost facts and show how modernization costs are self-liquidating.

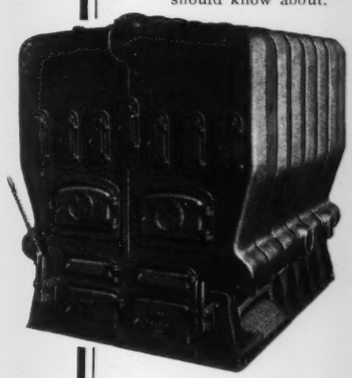
For replacing large steel boilers, you can in many cases use the Burnham Twin Sectional. Sections can be passed through the average door, overcoming all tear out costs. Leave the steel boiler in. Just install a Burnham Twin Section and pipe to it.

The Burnham Slenderized Radiators will give a distinct saving both in space-taking and fuel. The Burnham Bellows Radiator Air Valves will add to the efficiency because of their positive action and non-corrosive construction.

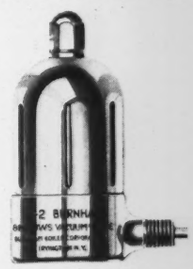
Send for Catalog 73. Get the facts. See for yourself how the Burnham Complete Line will give you the equipment to do a *self-liquidating* job.



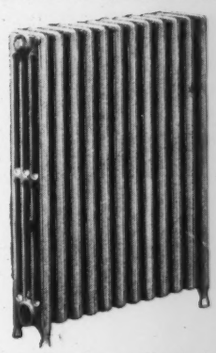
The Burnham Welded Steel Boiler has a reputation for fuel cost cutting that you should know about.



The Burnham Cast Iron Twin Section Boiler makes replacements an easy low-cost operation. Sections can be passed through any average door.



The Burnham Bellows Air Valve is positive in action. Made of non-corrosive metals.



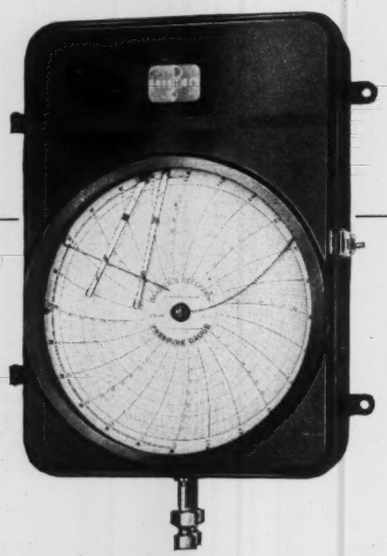
The Burnham Slenderized Radiators take up 40% less room. Heat quicker. Cost same as old tube-type that do much less and take up 40% more room.

Burnham Boiler Corporation

IRVINGTON, NEW YORK

Representatives in all Principal Cities of the United States and Canada

TWO PENS!



OFTEN you want to know not only what the pressure is, but how this is changing in comparison with some other pressure elsewhere.

For this purpose Bristol's Multiple-Record Gauge is used. It provides two records on the same chart. By the use of different colored inks, each record is distinctive. The pen arms pass each other without interference, or confine the ranges covered to separate areas without overlapping.

Furnished with charts 12, 10 or 8 inches in diameter.

Above: Bristol's Recording Gauge, Model 40M. Equipped with two pens for making two entirely different records on the one chart.

THE BRISTOL COMPANY, WATERBURY, CONN.
BRANCH OFFICES IN PRINCIPAL CITIES
Canada: The Bristol Company of Canada, Ltd., Toronto, Ontario.
England: Bristol's Instrument Co., Limited, London, S. E. 16

TRADE MARK
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REG. U. S. PAT. OFF.
PIONEERS IN PROCESS CONTROL SINCE 1889

For smaller buildings a single main valve is frequently sufficient, while for larger installations, separate valves are used for each heating zone.

The valves do not control by varying the steam pressure, but the steam volume, regardless of pressure fluctuations, as follows:

A small sealed tank, filled with air, serves as the outdoor thermostat and is connected to the valve by copper tubing. An increase in outside temperature expands the air in this thermostat, which puts a pressure on a bellows which expands and pushes the valve stem upwards, tending to close the valve.

Attached to the valve inlet is a venturi tube which is proportioned to provide a definite steam velocity to the valve. A pitot tube inserted in the throat of this tube receives the impact pressure of the steam and conveys it to the inside of auxiliary bellows.

The outside of this bellows is in communication with the valve body through a stem so that static pressure acts on the outside. The bellows therefore is actuated by the net velocity head, depending solely on the volume of steam flowing. The bellows is also attached to the valve stem and assists the outside thermostat in actuating the valve. By means of weights, the amount of valve travel is adjusted to suit local conditions, to enable the valve to balance itself at a point between open and closed.

Provision is made for closing the valve automatically, at any time the building is warm enough, although the outside thermostat may call for heat. The valve which is placed in the inlet to each individual radiator consists of a small disc with a special, automatically variable opening. A small flexible plate is mounted at a fixed distance in front of a port; this distance determines the amount of steam admitted to the radiator at minimum steam velocity. When the steam flow increases, the disc bends outward, thus increasing the opening. The result is a proportionate increase in the flow of steam to the radiator.

An adjustable gate on the inlet side of the graduator permits of adjustment of the initial opening, to assure a simultaneous flow of steam to all radiators, regardless of their distance from the steam supply.—Sarco Co., Inc., 183 Madison Ave., New York, N. Y.

Unit Steam Main Perfected

No. 602—Perfected unit steam main for underground distribution lines is an entirely fabricated unit, ready to install, light weight and water-tight. Conduit sections are of "Armco" iron, galvanized and asphalt coated. Unit is self-contained, including pipes, supports, liner, conduit sections, and insulation (if desired).

Advantages include less labor required in installation, least possible trench and pavement displacement, and less traffic delays, tending to lower total installed cost, states the maker; also, salvage value is nearly 100 per cent and entire system can, when desired, be moved to new location.—The Ric-wiL Co., 1562 Union Trust Bldg., Cleveland, Ohio.

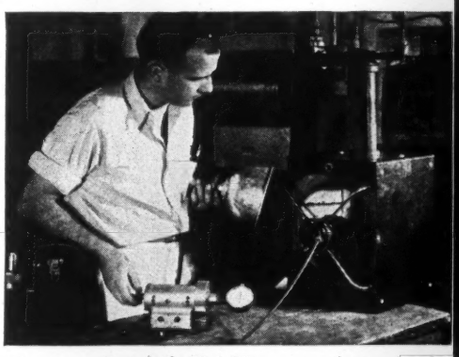
Sheave Sizes Added

No. 603—Additional stock sizes of "texsteel" sheaves for V-belt drives have been added, now making it possible to furnish "duro-brace texsteel" drives up to 15 horsepower.

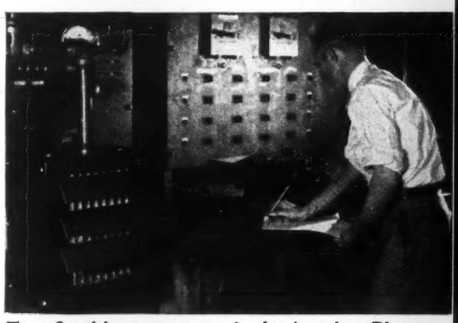
The grooves of the entire line are so designed that they can be used with A section belts ($\frac{1}{2}$"x$\frac{11}{32}$") or with B section belts ($\frac{21}{32}$"x$\frac{7}{16}$") depending on the application. The standard line now includes 25 different diameters of sheaves from 3 up to 18 in. inclusive for any number of grooves from 2 to 6 inclusive, or 125 different sheaves. All are now available with interchangeable type hubs which are carried in stock with bores in $\frac{1}{16}$ in. increments from $\frac{1}{2}$ in. up to the maximum bore.—Allis-Chalmers Mfg. Co., Milwaukee, Wis.

AMERICAN BLOWER ENGINEERS

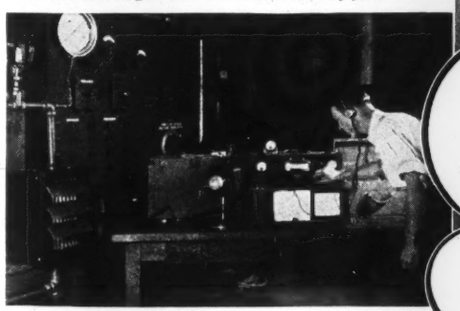
develop amazing new heating results



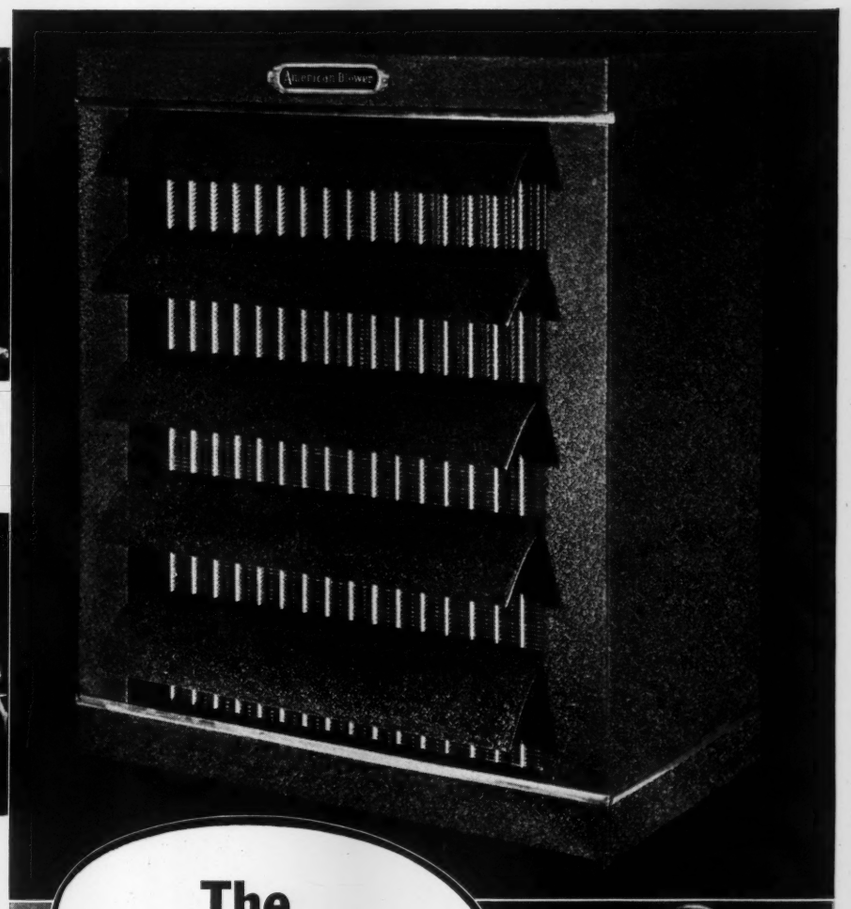
These new Venturafin Unit Heaters are the result of 50 years' experience. They are tested in accordance with the standards of the American Society of Heating and Ventilating Engineers and are given numerous other tests. This shows a Stroboscope test to detect undue vibration or performance deficiencies.



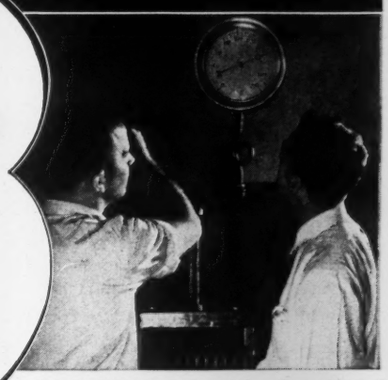
Top: Sensitive watt meters in the American Blower research laboratories record the power input of the new Venturafin Units. Bottom: This extensive sound equipment which records and rates Venturafin Units for sound, eliminates guesswork and makes it possible for you to select the proper Unit to conform with the existing sound conditions of any job.



The new Venturafin Unit Heaters feature:—New Beauty—Morocco Finish with Stainless Steel Trim. Quieter Operation—The 1st unit heaters with definite sound ratings. New Standards of Efficiency—10 to 64% more heat, 4 to 45% more air with no increase in horsepower.



The 1st unit heaters with definite sound ratings



Venturafin Units are tested and guaranteed for 150 lbs. steam pressure. Before you buy any new heating equipment or take steps to modernize your present heating equipment, mail the coupon for all the data, prices, etc., on the new Venturafin Units.

Venturafin Units are carried in stock in all principal cities—ask your heating contractor or mail the coupon for data

American Blower

"Sirocco" VENTILATING. HEATING. AIR CONDITIONING. DRYING. MECHANICAL DRAFT

DIVISION OF AMERICAN RADIATOR AND STANDARD SANITARY CORP.

American Blower Corp., 6000 Russell St., Detroit, Mich.

Please send complete data on the new Venturafin Unit Heaters to:

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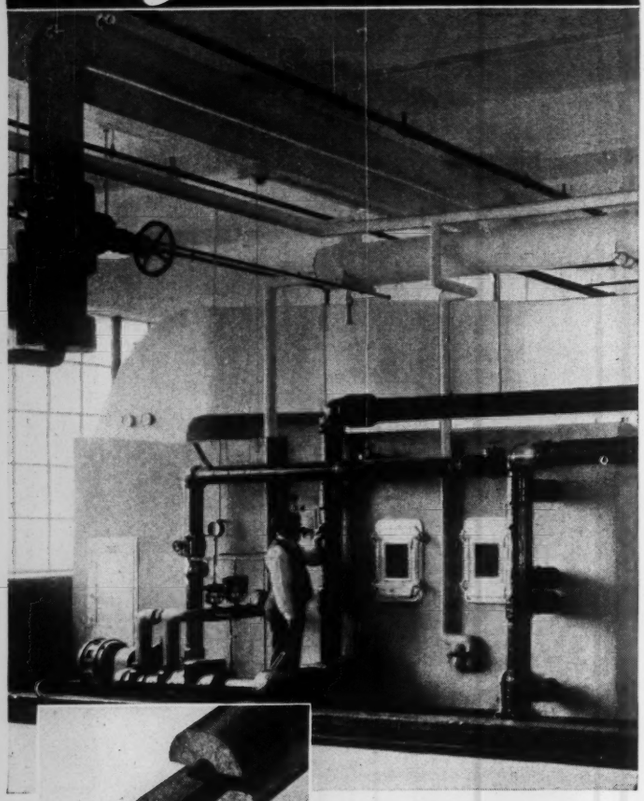
MUNDET Jointite TRADE MARK CORK PRODUCTS



Above is partial view of the air conditioning unit in the modern Daily News publishing plant, Brooklyn, N. Y. Illustration shows "Jointite" Pipe Covering with canvas and mineral rubber finishes.

TO secure efficient operation and permanent protection, all cold lines and ducts in the air conditioning system of the *Daily News* have been insulated with "Jointite" Corkboard and Moulded Cork Pipe Covering.

The surest way to obtain economical temperature control is to specify cork insulation. Mundet Cork products are made of 100% pure cork, the finest grade obtainable. They offer to the Air Conditioning Industry the same high quality and low transmission coefficient per inch of thickness that have maintained universal acceptance for Mundet cork insulation.

★ MUNDET NATURAL CORK ISOLATION MATS solve the problem of machine vibration. Write for a free copy of our Catalog, or refer to Sweet's Architectural Catalog.

MUNDET CORK CORP.
A National Organization — Offices in Principal Cities
450 SEVENTH AVENUE, NEW YORK, N. Y.

New Packless Expansion Joint

No. 604—New packless expansion joint known as "U-Ring" type is based on new principle for controlling expansion in steam and hot water lines, or lines conveying gases or fluids subject to temperature variations. Expansion element is a series of die-formed "U-rings" of stainless alloy steel, welded together without transverse seams by a special process. One end is welded to the wrought steel body of the joint and the opposite to a plate welded to the sleeve.

Joint is installed with expansion element compressed so that under operating conditions it is in a neutral position free from flexing strain when under maximum line pressure. Control rings and stop-bolts distribute the expansion and contraction movement equally, and joint is guided at three points to permit sleeve to move freely. Wrought steel body encloses expansion element, protects it from damage or dirt.

Available for pressures to 400 lb and temperatures to 800 F with flanged or beveled welding ends, with or without anchor base. Normal traverse range is 1 in. to 8 in.—American District Steam Co., North Tonawanda. N. Y.

New Engine Driven Welder

No. 605—New 200 ampere special engine driven "Shield Arc" low-priced welder supplies uniform current for welding with bare or heavily coated shielded arc type electrodes in all sizes up to ¼ in. Welding current range is from 60 to 250 amperes. Generator is single operator variable voltage type with completely laminated magnetic circuit and equipped with interpoles. Requires no external reactance or stabilizer. Dual control of welding current is provided by adjustment of both series and shunt fields. Separate excitation of the generator shunt fields is supplied by an exciter connected on the generator end of the unit. A generator field rheostat and a current regulating switch are mounted in vertical position on a "dead-front" steel control panel. Electrode and ground cable connections of the wing nut type are also in an easily accessible position.—The Lincoln Electric Co., Cleveland, Ohio.

Balancing One-Pipe Heating Systems

No. 606—Variable vent valve for balancing one-pipe steam heating systems, known as "Vari-Vent," makes use of a needle valve construction which, says the maker, allows straight line control in that infinite regulation is allowed between fixed limits. The needle valve is raised or lowered to provide the necessary adjustment.—The Dole Valve Co., 1901-1933 Carroll Ave., Chicago, Ill.

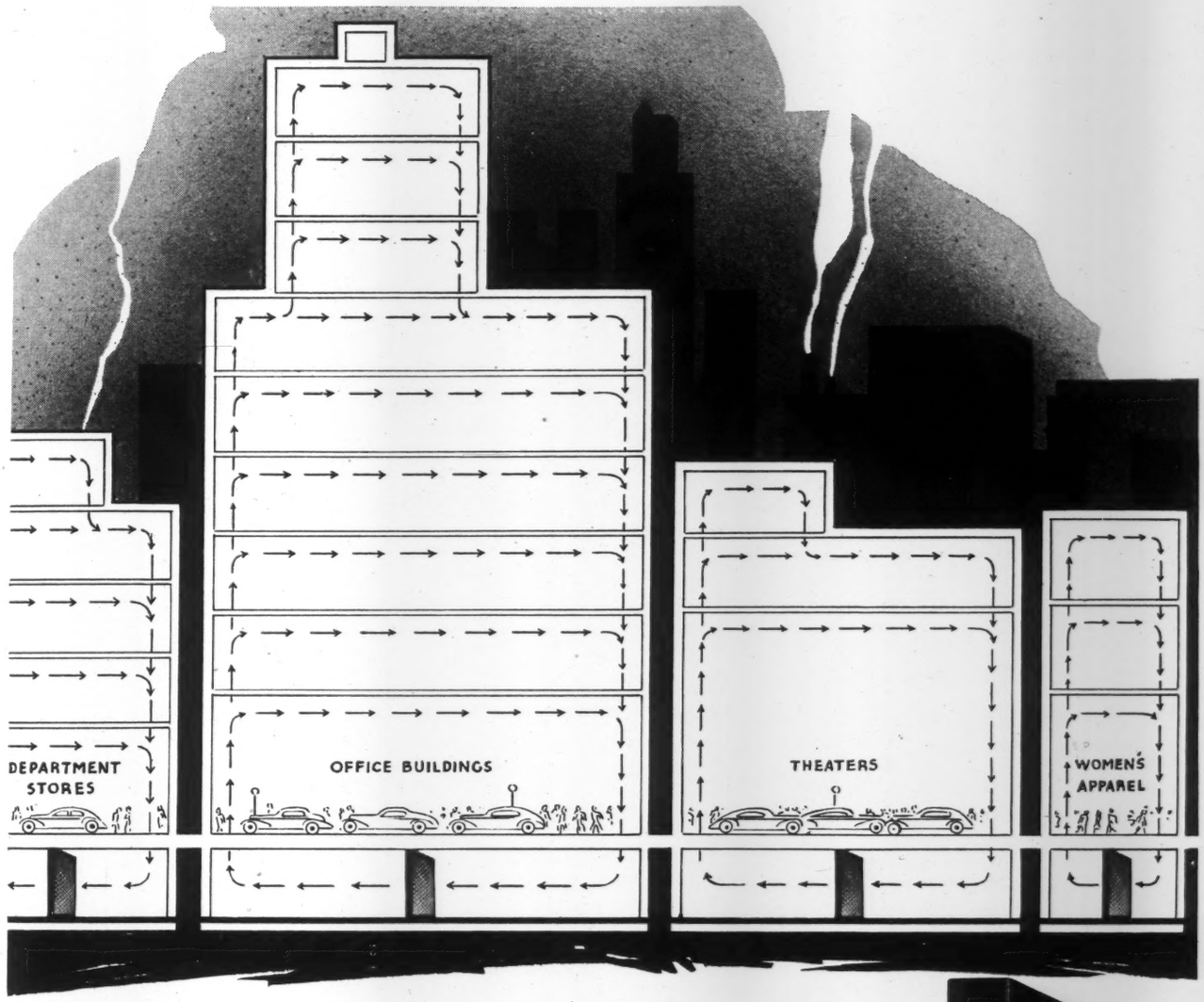
Angle Switching Controls Compressor Motors

No. 607—Angle switching equipment for controlling large synchronous motor driven reciprocating pumps and compressors to prevent the compression strokes on different units occurring in unison has been developed. Employing an electronic tube, this new device effectively reduces the magnitude of current pulsations where two or more drives are used. Minimum pulsations are desirable to reduce flicker in lights and interference with the operation of other electrical equipment.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

New Sawing Vise Set

No. 608—New "Trimo" sawing vise set for holding, sizing and cutting thin wall copper and brass tubing cuts 100 per cent square to insure a perfect bearing against the fitting shoulder, states the maker; saw blade is held in close guides against and all around tubing while cut is being made. Tubing is sized and held to round while being cut, and both ends of tubing are held from sagging and prevented from forming "break-off burr" or "flat lip" at completion of cut.

Set is made up in units of from ⅜ to 2 in. for welding, brazing or sweat fitting jobs in industrial and air conditioning work. —Trimont Mfg. Co., Roxbury, Mass.



MAIN STREET gets CLEAN AIR at *lower cost* through DUSTOP

● The nation-wide demand for *clean air* is increasing by leaps and bounds! Dustop replacement type air filters are highly efficient, fire resistant, easy to install—at a cost of only 1c per c.f.m. including filters, all frame members, nuts and bolts. Dustop's low maintenance cost is only 3/10c to 4/10c per c.f.m. per year. Distributors, carrying complete stocks of Dustop replacement filters, located in all principal cities. (Dustop is distributed in Canada by General Steel Wares, Ltd., Toronto.) Owens-Illinois Glass Company, Industrial Materials Division, Newark, Ohio.

OWENS-ILLINOIS DUSTOP AIR FILTERS

Stoker, Pump and Air Compressor Controls

No. 609—Timed interval, single unit combustion control for stokers ("Penn Type 550") is rated for ½ hp single phase 110 volts a-c service to handle directly domestic and semi-commercial stoker installations, and may be used as a pilot control for stokers rated in excess of this switch rating.

Control incorporates transformer which supplies low voltage to the control circuit, a synchronous electric timer and a relay. The timer automatically restarts upon return of current following current failure.

Timer operates in conjunction with room temperature control to maintain combustion without materially affecting room temperatures and without unnecessary fuel consumption, regardless of outside weather conditions, states the maker.

The same company has recently introduced two new controls for pump and air compressor service up to 80 lb maximum pressure, regularly provided tapped for ¼ in. standard pipe thread pressure connection, but available in ⅛ or ⅜ in. tapped connection. Both are double pole, double break switches.

The "Type 140" incorporates bimetal overload protection with patented trip-free reset button. When this button is depressed to reset the trip-out mechanism, the contacts are blocked open and held in open position until the button is released. Thus it is impossible for a user to block the contacts closed in any manner, preventing burned out motors—Penn Electric Switch Co., Des Moines, Iowa.

Boiler Repair Solder

No. 610—Boiler repair material ("Sodrin") is a synthetic solder made from a base of pure aluminum, and has the property of melting in hot water and hardening when cooled at the leak by air. Circulation of water in a boiler or piping carries the solder to the leak. For steam boilers, it is inserted in the water line near the leak, the boiler is fired to about 3 lb, and pressure held until the solder solidifies.—The Dole Valve Co., 1901-1933 Carroll Ave., Chicago, Ill.

Schoolroom Units

No. 611—New "Air-O-Lizer" unit ventilator for schoolrooms incorporates directional flow grilles to direct the heated air into the room in any desired direction so that intervening windows and bare wall spaces may be blanketed with heat to eliminate cold spots and drafts. Grille is in the top of unit and is composed of main or central section, and two smaller end sections which may be turned to any desired angle.

Other features include ventilated pipe spaces to prevent freezing and increase the efficiency of the unit ventilator, one piece light weight balanced aluminum dampers lined with felt, multiple fans with full floating mounted shafts to eliminate noise and vibration. Unit is sound-proofed, insulated and the motor and power unit are cradled in felt.—The Trane Co., La Crosse, Wis.

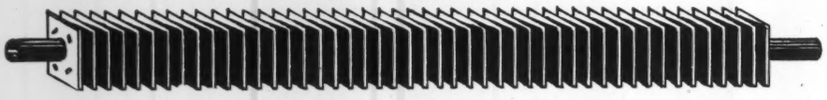
Self-Cleaning Spray Nozzle

No. 612**—New spray nozzle designed for humidification use, or for any place where spray with low viscous liquids is required, operates on pressure of 35 lb or more, passes approximately 6 quarts per hr through the nozzle.

Orifice is automatically cleaned each time the water is shut off, accomplished by means of a spring action piston in the end of which is the orifice, and a cleaning pin. The piston moves forward when the water is turned on and returns to its original position by spring action when water pressure is released forcing the cleaning pin into the orifice. Can also be furnished to impinge a fine stream on a baffle plate, operating on pressure of 25 lb or more.—Rega Mfg. Co., 79 Mt. Hope Ave., Rochester, N. Y.

BUSH FINNED TUBING
FOR EVERY HEAT TRANSFER PURPOSE

OUR STANDARD LINE HAS 38 COMBINATIONS OF PRIME AND SECONDARY SURFACE



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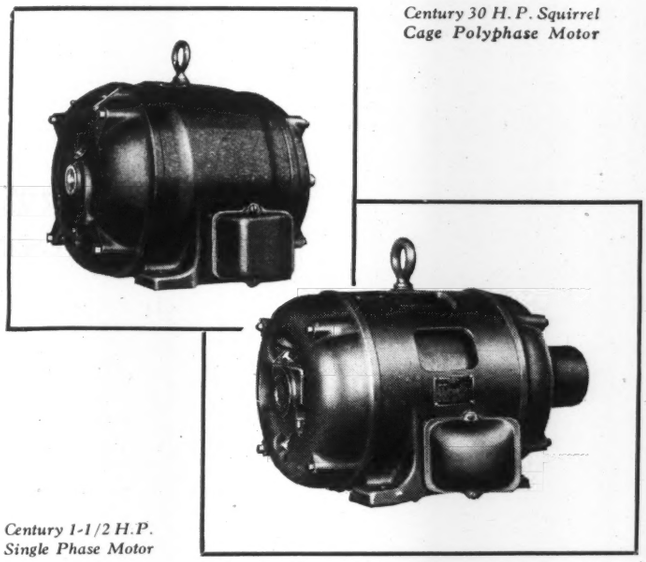

Century 30 H. P. Squirrel Cage Polyphase Motor

Century 1-1/2 H.P. Single Phase Motor

AIR CONDITIONING

Ask Anybody! . . . For more than 30 years Century Motors have played a leading part in assuring the satisfactory operation of Pumps, Refrigerators, Compressors, Fans, Blowers and similar equipment which is now grouped under the general heading "Air Conditioning".

It stands to reason that this wide experience and demonstrated ability to meet all the demands of the individual equipment offers conclusive assurance of Century's ability to meet all the co-ordinated demands of the grouped equipment. A complete line of motors—in a wide variety of types adapted to the majority of industrial applications—in any desired mounting—in sizes up to 600 Horse Power!

Send for Century Bulletins—Consult Century Engineers.

CENTURY ELECTRIC COMPANY
1806 Pine Street St. Louis, Mo.
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Century
MOTORS 1/250 TO 600 H. P.

CITY AIR—
MADE Clean
AS AIR IN THE
MOUNTAIN PINES
with the Coppus
Self-Cleaning Filter
97% of city dust consists of tiny particles (3 microns and smaller) that slip through the ordinary filter. By actual dust count of filtered air (the sure test the Government uses)—no type of filter is as efficient as the Coppus Dry-Matic. Dust count tests have proved that the Dry-Matic stops 88.6% of all dust particles 2 microns in size (a micron is 0.00004") and smaller.
This filter has the great added convenience of cleaning itself automatically. And there's no replacing of filter cloths—no messy cleaning of sludge pans.
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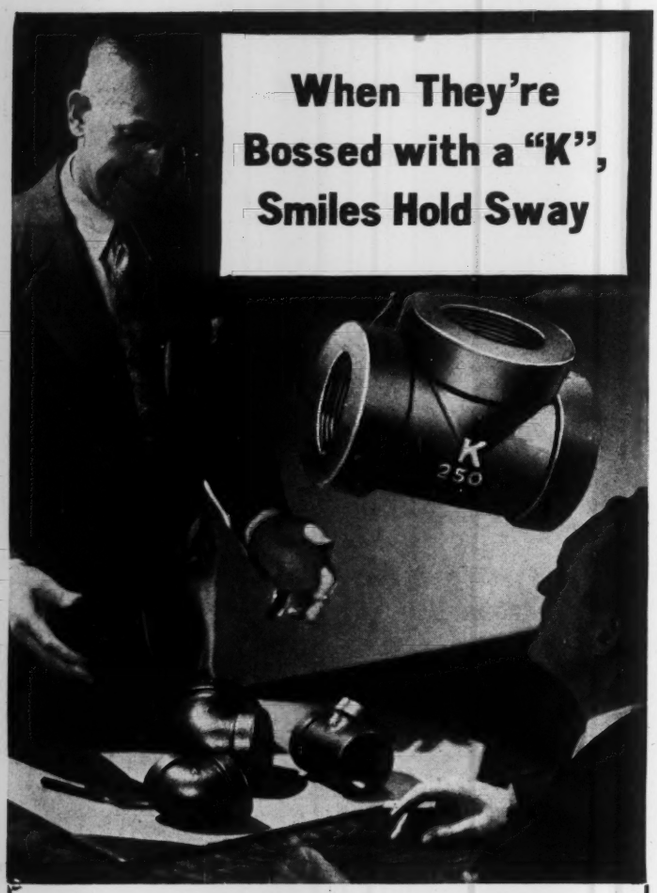
374 PARK AVE., WORCESTER, MASS.

"The Dry-Matic Is Its Own Caretaker"

1929



In Other Words—

There's experience in them—47 years of it.

There's iron of the right analysis in them.

They're close of grain and smooth and clean.

They're hand inspected and, being accurately threaded and chamfered, they're guaranteed to make up easily and pull tight—the significance to you of that "K" on the casting.

Complete Line in Heavy Production

Standard and Extra Heavy Screwed Fittings,

American Sprinkler Fittings, Standard Flanged Fittings,

Standard and Extra Heavy Companion Flanges, Drainage Fittings,

Strict adherence to M. S. S. standards.

Combined marketing facilities on both "K" cast iron and on M. I. F. malleables. Complete stocks of both at Dayton, Ohio, and Branford, Conn.

KUHNS BROTHERS COMPANY, Dayton, Ohio

K Cast Iron Fittings Since 1887

Catalog for Plumbers and Industrial Users

New Line of Exhaust Fans

No. 613—New line of exhaust fans, known as "Macheta Airfoil" comes in a wide variety of ratings through various combinations of blade numbers, pitch ratios, and speeds. These fans are applicable to ventilation, heat and vapor removal, space and man cooling, drying, and air conditioning.

Two, four and six blade types, direct connected or belted, are available. The design is fully described in a recently issued bulletin.—Aerovent Fan Co., Piqua, Ohio.

Acetylene Cylinder Manifold; Acetylene Generator

No. 614—New wall type acetylene cylinder manifold ("Oxweld Type M-8") is available in a ten cylinder unit to which extensions in units of five cylinders or ten cylinders can be made. Manifold consists of two high pressure header units which feed into a central regulation system which delivers acetylene to the distribution piping system at pressures up to 15 lb per sq in.

A new small size medium pressure acetylene generator for portable or stationary service also has been announced. It has a 50 lb carbide capacity with a double rating of 100 cu ft of acetylene per hr and was developed for portable or stationary use with any type of oxy-acetylene cutting or welding apparatus.—Linde Air Products Co., 30 E. 42nd St., New York, N. Y.

Air Meter for Field Use

No. 615—New "Air Meter" gives direct readings of static pressures, velocities, drafts, cfm, etc., and was designed for field use in heating, ventilating and air conditioning work for velocities 140 to 2,832 fpm, pressures or vacuums from 0.00125 to 0.50 in. of water. Among the applications are balancing duct systems, estimating required cfm, obtaining total pressure, static pressure, duct velocity, cfm, static loss in a system, filter or air washer, checking chimney draft, etc. Zero correction and leveling device are integral.

Complete in a portable case 3¼ in. by 3¼ in. by 14¾ in., the instrument has a net weight of 2 lb, 3 oz.—Julien P. Friez & Sons, Inc., Baltimore, Md.

Timing Relay for Compressor Starting

No. 616—Timing relay designed for those applications where a timing interval between the functioning of two or more electrical circuits is required may be used in connection with air conditioning where two or more compressors are used to promote economical operation. Allows each compressor to reach full operating speed before the next compressor starts, reducing the demand load, and frequently making possible the use of existing wiring in a building instead of installing new lines.

The time interval is provided by a sealed thermal relay which actuates an auxiliary magnetic contactor, the assembly being mounted in a metal box with terminal board. Available for use on 115 or 230 volts, a-c or d-c.—Edison Electrical Controls Div., Thomas A. Edison, Inc., West Orange, N. J.

Glass Block for Buildings

No. 617—Development of an improved "Insulux" glass block for building purposes, which has stood up under pressure of 72,500 lb to a single block and which reduces heat flow, deadens sound, transmits and diffuses light, deflects sun glare and resists fire was announced recently.

Variations of light transmission are obtained through a variety of face cuttings on the block. Depending upon the face cutting, the blocks transmit as low as 11.7 per cent and up to 86.5 per cent of the light falling upon them. The blocks also practically eliminate condensation on the inside walls, it is stated. Tests showed no sweating when the outside temperature was 16 F below zero with an inside temperature of 70 F and 40 per cent humidity. Tests of a 3⅞ in. wall indicated a heat transmission coefficient of 0.29 Btu per hr per sq ft per F difference in temperature.—Owens-Illinois Glass Co., Insulux Div., Muncie, Ind.

NEW—
UP-TO-THE-MINUTE!

Lewis' New

"Air Conditioning for Comfort"

By Samuel R. Lewis

277 Pages—$2.50
Large Psychrometric Chart

Giving full consideration to the very latest air conditioning methods, equipment, and design practices, this enlarged, second edition of Samuel R. Lewis' popular book is, in every respect, the very last word on comfort air conditioning.

From this book anyone may quickly acquire a thorough, up-to-date, and accurate knowledge of the comfort air conditioning science. In clear, concise language, Lewis presents all those facts and data relating to equipment, psychrometry, refrigeration, humidifying, dehumidifying, the human body, heat transmission, heat absorption, air volumes, air distribution, water circulation, and operating costs that the engineer must know and understand in order to correctly design year 'round air conditioning systems for both residences and large buildings.

Two complete examples of air conditioning design work are presented in the book. Selecting a typical residence, and a new office building housing a bank, offices, stores, cocktail lounge, restaurant, and kitchen, Lewis works out the heating and cooling load calculations for both in their entirety, using record sheets which make it easy for the reader to follow every step.

All engineering data required for air conditioning design calculations are included in "Air Conditioning for Comfort." Scores of charts, tables, and formulas are given. The proper application of each of these data is made clear by actual examples. A whole chapter is devoted to the formulas for psychrometric computations covering humidifying and dehumidifying, while another explains the estimation of operating costs, and includes a curve of operating hours for cooling plants based on design wet bulb temperature.

No one who carefully reads this book can fail to gain a comprehensive understanding of just what air conditioning is, how it works, what it costs, and how to proceed in the designing of satisfactory systems. A copy belongs in the hands of every one interested in or doing air conditioning work.

Send $2.50 for a copy today. If it does not come up to your every expectation, return the book within 10 days and your money will be refunded.

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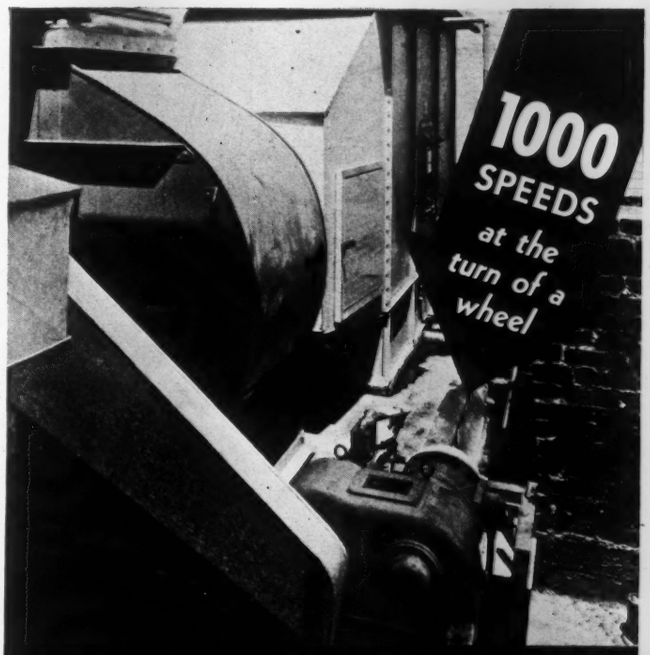
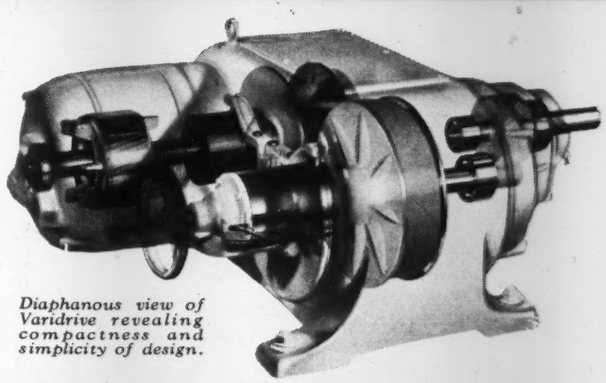
6 N. Michigan Ave., Chicago, Ill.



U.S. *Varidrive* MOTOR
DEVELOPED FOR THE VENTILATING INDUSTRY



Diaphanous view of Varidrive revealing compactness and simplicity of design.

Variable Speed for Fans

Speed of fans can be varied to the precise speed required, making it unnecessary to operate part of the time above the correct speed and part below. The Varidrive offers *instant* change of speed. It operates quietly. The speed is changed merely by pressing a button or by turning a wheel, locally or from a remote control. The U. S. Varidrive Motor operates economically; no power consuming resistance or rheostats are used. There are no brushes to wear out or slip-rings to refinish. This motor is self-contained, occupying little more space than a single motor. It is a simplified variable speed unit long needed by the ventilating industry. Our new illustrated Bulletin completely describes and illustrates this revolutionary motor. Send the coupon for a copy.

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The Editor's Page—

[*Continued from page 27, front section*]

Equipment," Glenn Muffly; "Pipe Line Air Conditioning," Nels H. Rosberg; "New Installation in Gimbel-Saks Stores," C. S. Leopold; and "Proposed Standard for Rating and Testing Mechanical Condensing Units," L. S. Morse. . . . A debate—"Should Engineering Be a Closed Profession?" (that is, in the sense that the profession controls its numbers and qualifications)—will be a feature of the meeting.

Air conditioning increases attendance and should go far toward reviving interest in the stage during summer months, according to the management of Henry Miller's Theater, New York, recently air conditioned legitimate playhouse. . . . An unusual 5½ story New York apartment building, utilizing glass block construction, will have two air conditioning systems, one for each apartment. . . . A studio will occupy the ground floor. . . . H. G. Wells predicts air conditioning for every office and residence a century from now in his book *Things to Come*. . . . Seems rather conservative, at least insofar as offices are concerned.

An article in a recent issue of the *Baltimore & Ohio Magazine* describes how air conditioning has revolutionized the sales appeal of American railroads, emphasis now being placed on comfort. The railroads have done a real job in attracting interest and patronage with air conditioning, a job that many another business can well—and are, in some cases—emulate. . . . The proceedings of the homes conference held last June at the Purdue Research Foundation have been published by the Foundation as a 56 page booklet. . . . The Policyholders Service Bureau of the Metropolitan Life Insurance Co., New York City, recently issued a report entitled "How Equipment Manufacturers Provide Against Inadequate Specifications in Customers' Orders."

There is no reason why a heating or air conditioning plant can't be neat and attractive in appearance as well as efficient. A good job ought to look good. It is more confidence-inspiring, gets better maintenance attention. Such plants are called upon to do some pretty dirty work in many cases but it is worth the effort and slight expense to keep them clean and painted.

Conventions and Expositions

International Acetylene Association: Annual convention, Nov. 12-15, Cleveland Hotel, Cleveland, Ohio. Secretary, H. F. Reinhard, 30 E. 42nd St., New York, N. Y.

American Society of Refrigerating Engineers: Annual meeting, December 4-6. Hotel Pennsylvania, New York, N. Y., Secretary, David L. Fiske, 37 W. 39th St., New York, N. Y.

Welding Conference: December 5-6, Purdue University, LaFayette, Ind.

American Society of Mechanical Engineers: Annual meeting, December 2-6, Engineering Societies Bldg., New York, N. Y. Secretary, C. E. Davies, 29 W. 39th St., New York, N. Y.

International Heating & Ventilating Exposition: January 27-31, International Amphitheater, Chicago, Ill. Manager, Charles F. Roth, Grand Central Palace, New York, N. Y.

American Society of Heating and Ventilating Engineers: Annual meeting, January 27-31, Palmer House Hotel, Chicago, Ill. Secretary, A. V. Hutchinson, 51 Madison Ave., New York, N. Y.

National Warm Air Heating and Air Conditioning Association: Winter meeting, January 27-29, Hotel Stevens, Chicago, Ill. Managing Director, A. W. Williams, A. I. U. Bldg., Columbus, Ohio.

Southern Industrial Show: April 6-11, Textile Hall, Greenville, S. C. Wm. G. Sirrine, President.

Use RIC-WIL Unit Steam Main

for Economy and Speed on UNDERGROUND DISTRIBUTION SYSTEMS

IMAGINE a fully fabricated, ready-to-install underground steam main! The construction factor virtually eliminated. Durable, compact, light-weight, water-tight, self-contained. Completely assembled at factory, including pipe, supports, insulation, liner and conduit. Each Unit equipped with expansion and anchor device to eliminate manholes, if desired; or, we furnish fabricated manholes with standard expansion and anchor devices, complete. Shipped in units of 13½ ft. in length. Armco Iron, galvanized and asphalt coated, used for conduit sections. Famous genuine Ric-wiL waterproof Asbestos Dry-PaC insulation. Ric-wiL tile cradle base drain foundation optional.

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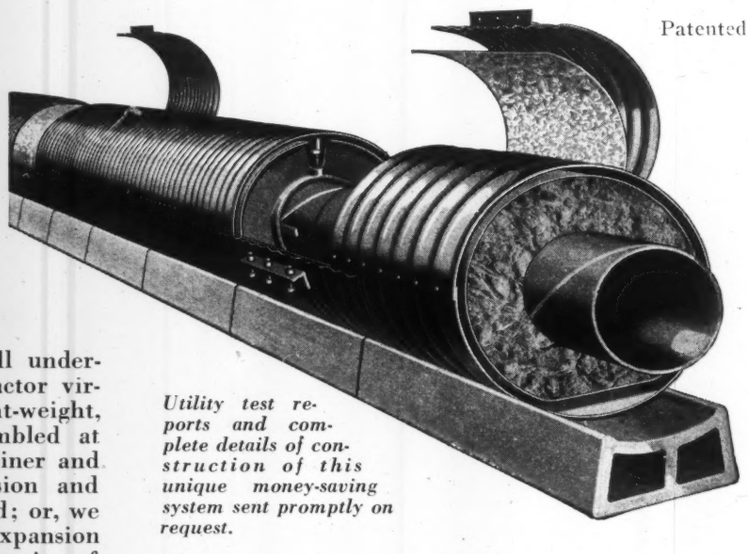

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Factory assembly cuts field labor costs. Practically all work done with common labor and welder. Trench and paving displacement the absolute minimum. All sections marked for proper placing. Total installed cost the lowest at which a durable system can be obtained. Reclamation value practically 100%—entire system can be moved and installed elsewhere. Special units furnished to specifications.

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Aerofin is years in advance of ordinary heating and cooling surface because of its exclusive features. It is available in aluminum, copper or other special metals. Whatever you have wished for in a fan system surface you will find in Aerofin.

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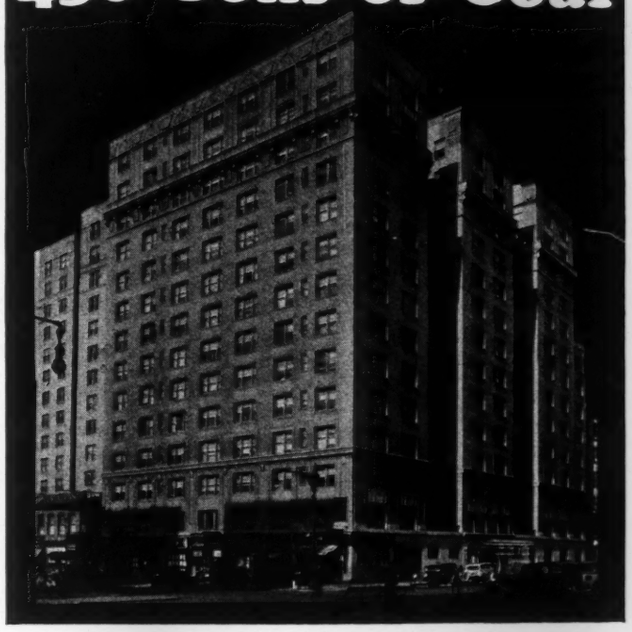
Sarco Saves 450 Tons of Coal



A most interesting example of how it pays to modernize heating systems is that of the 15-story apartment house pictured, located at Broadway and 98th Street, New York, and owned by Metropolitan Life Insurance Company.

The saving of 450 tons in one heating season represents one-third of the fuel consumed in a normal heating season. It was accomplished at a relatively trifling cost and without inconveniencing the tenants, by fitting each radiator inlet valve and trap with a Sarco Adapter. New Sarco float-thermostatic traps were also installed on all risers and at the ends of the steam mains.

It was then easy to maintain a vacuum on the system, resulting in quick circulation of the steam to all radiators, at reduced pressure. The increased comfort for the tenants has improved the occupancy of this building.

Sarco adapters are guaranteed to make old radiator traps of any make equal to new in steam saving. They consist of a cap and motor element which can easily be fitted into any trap or inlet valve without disturbing the pipe connections.

See our Exhibit at Booth 144, International Heating & Ventilating Exposition, Amphitheatre, Chicago, Ill., January 27th to 31st, 1936.

Write for Booklet O-111

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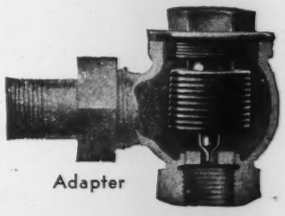
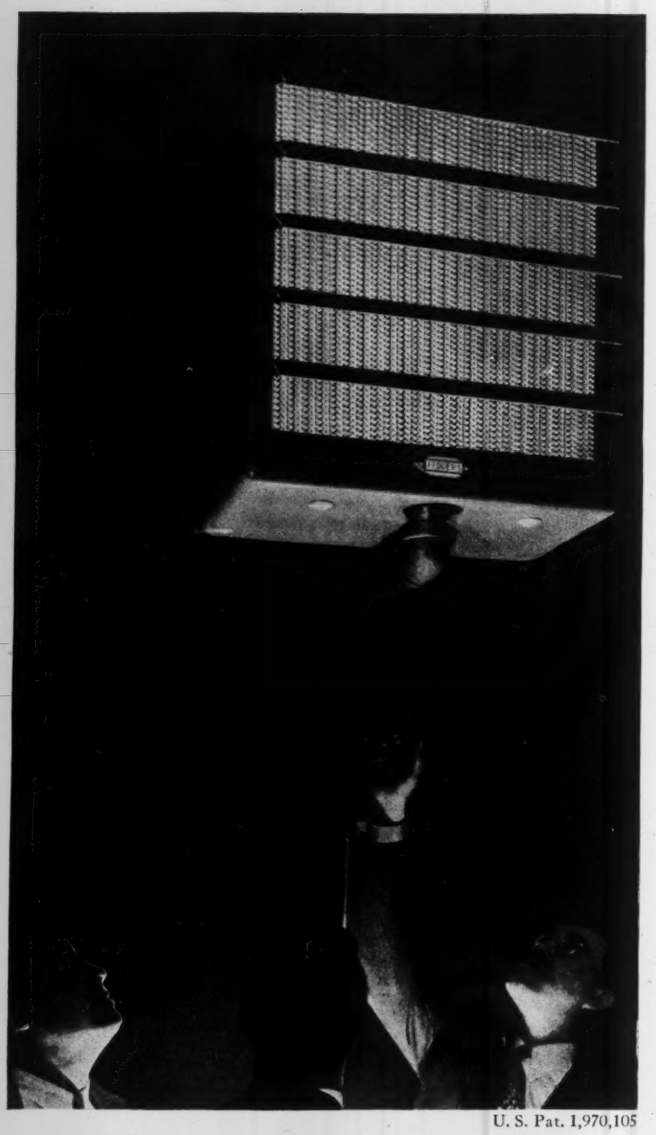
Branches in Principal Cities
Sarco Canada Limited, Federal Bldg.
Toronto, Ont., Canada



Adapter

SARCO Heating System



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Their handsome appearance and quieter operation open up the commercial market in addition to industrial uses.

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Trouble Shooting—

[*Answer to trouble job described on pp.* 528-529]

As we were cleaning up preparatory to leaving, from somewhere within the dark recesses of the mind came a memory of an ordinary desk fan set on the floor blowing against a radiator in order to condense steam more quickly and heat an otherwise chilly room. Could it be possible that the ventilating fan provided a brisk enough air movement around the return mains to condense the steam so fast that it was impossible to build up steam pressure in the return mains to the full boiler pressure? After all, there was a very large area of return pipe exposed in the plenum chamber and a very restricted connection feeding steam from the supply main into the return main. In addition, the return main was hung almost directly below the exhaust mushrooms.

Instructions were given to stop the supply fan and then have the boiler fired up again. As the pressure slowly rose, the water line held steady and the boiler reached 10 lb pressure. Very much encouraged, we repeated the test with the same result. No water was lost from the boiler even though the pressure reached 12 lb. To make doubly sure the boiler was checked and the pressure allowed to fall to 1 lb. The fan was started and the boiler fired. By the time the pressure reached 7 lb, the water had completely disappeared from the gauge glass as usual.

Cause of the trouble was now apparent. The uncovered steam mains condensed much more steam with the air moving around the pipe than the ½ in. connection at the end of the steam main was able to feed into the return main. While this may seem puzzling, it can best be understood by reference to Fig. 3, which

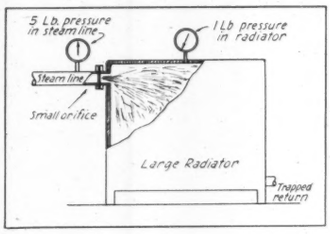

Fig. 3—Illustrating the principle which caused the trouble

illustrates a large radiator fed by a pipe with a very small orifice in it. With, say 5 lb steam pressure in the pipe line, it would still be impossible to maintain more than 1 lb pressure in the radiator. Due to the small size of the orifice it would take a pressure differential across the orifice of at least 4 lb to feed as much steam into the large radiator as the latter was condensing. This was precisely what was happening in the return main, which had a comparatively large exposed area, through which the heat transfer was accelerated due to the brisk air movement in the plenum chamber.

Instructions were given to insulate all the return mains. At first, we considered advising cross connections between the steam main and the return line at various points, but decided not to attempt this for fear of difficulties with steam circulation and water-hammer. In addition the theater might have difficulty with overheating in mild weather due to the steam in the return. Since they had already experienced a little trouble from this source, insulation seemed to offer the most satisfactory cure.

After the return mains were insulated, no further difficulties were encountered. The fan could be run at full speed and the boiler pressure carried at 10 lb without losing any water.

In the article "Air Conditioning Fundamentals" by Louis A. Harding in the September, 1935, H. P. & A. C., the division sign (/) in Eq. 1 and in the preceding equation on page 430 should be replaced by a multiplication (×) sign. The numerator of Eq. 2 should be multiplied rather than divided by 778.

FRETZ-MOON PIPE

The standard for uniformity

There are two reasons for the high uniformity of Fretz-Moon Pipe. First, the steel skelp from which it is made is specially rolled from steel of evenly high quality. Second, the exclusive "continuous process" by which it is made takes advantage of the most modern methods of speed and temperature control and entirely eliminates guesswork and the possibility of variation in the product.

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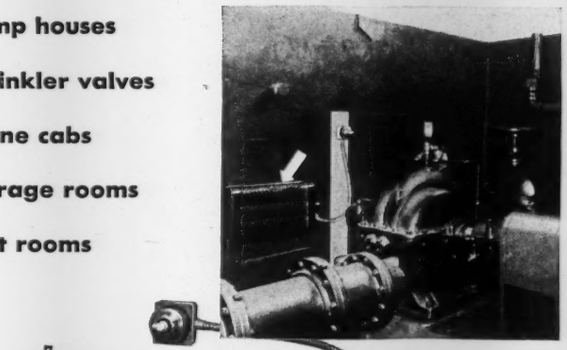

G-E industrial air heaters will help you solve your winter heating problems. They are economical—no standby losses; always available—not dependent on boilers; easy to install—no steam piping to run; low in maintenance—strongly built; portable—heat where you want it; simple to operate—just turn the switch.

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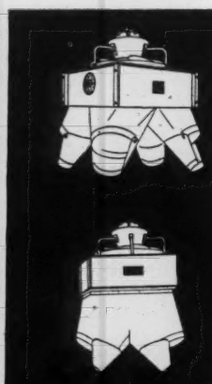
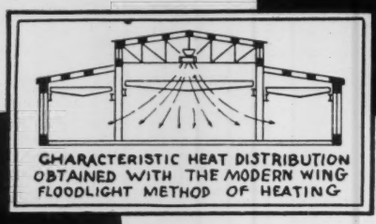
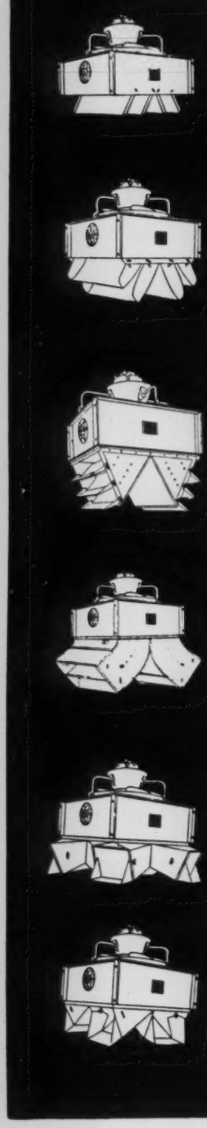


A discharge outlet to suit every space



CHARACTERISTIC HEAT DISTRIBUTION OBTAINED WITH THE MODERN WING FLOODLIGHT METHOD OF HEATING



Keen competition is, today, turning the attention of industrial executives and commercial building owners more and more to the problem of reducing maintenance costs to a minimum.

Heating systems and methods are not being overlooked, for informed and progressive managements are demanding: the heating system that will not interfere with production equipment or take up valuable floor space—that delivers a uniform invigorating temperature over the entire working area—that eliminates the concentration of useless (wasted) heat in the upper areas of the room or building.

The Wing Floodlight Method is the ONE system that is designed to overcome these vital deficiencies of the ordinary methods of heating.

It will pay you to recommend and specify this advanced method of heating—write today for complete information.

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WING *Floodlight* HEATING

Booklets, Reports and Papers

Lubrication of Air Conditioning Equipment

"Lubrication of Air Conditioning Equipment," Vol. XXI, No. 8 of the publication "Lubrication" regularly issued by The Texas Co., 135 E. 42nd St., New York, N. Y. 16 pp., 7 x 10 in.

This summary of the lubrication problems in connection with refrigerating compressors (both reciprocating and centrifugal), fans, and motors contains a great deal of information in few words. Types of equipment requiring lubrication are described, miscibility of refrigerants with lubricating oils discussed, and the factors governing absorption of "Freon" by lubricating oil described. Lubricating oil requirements for this work are explained under the headings viscosity range, flash point, corrosion and resistance to breakdown, and the physical effects of temperature upon oils and the effect of wax content are summarized.

The splash, pressure and ring oiler methods of lubrication of air conditioning compressors are briefly described with notes on design and operation for best results, as is the use of piston rings. The report concludes with several paragraphs on motor and fan bearing lubrication.

Properties of Ammonia Solutions

"Properties of Ammonia Solutions (Aqua Ammonia Tables and Chart)," prepared by A. B. Stickney, Engineer, Armour & Co., and published by the American Society of Refrigerating Engineers, 37 W. 39th St., New York, N. Y. 1 p., 1 chart, 2 tables. 8½ x 11 in. Price, 15c.

Probably due to lack of correlation of the available data in compact, readily understandable form the absorption ammonia cycle is possibly the least understood, from the quantitative standpoint, of those with which the refrigerating engineer deals. To make the data readily usable, the present chart and table on thermal properties of ammonia—water solutions have been developed, based upon the work of Bosnjakovic, Wucherer, Zinner, and others. Use of the information presented is briefly explained.

New Psychrometric Chart

The air conditioning department of the General Electric Co. has announced a new, improved psychrometric chart which is the result of research and experiment to develop a chart which would be more practical in form and which would simplify the reading of charted values. Values of all characteristics can be read, from any stated point on the chart, without the use of auxiliary curves.

Designed for permanent use, the chart measures 14x20½ in. and is printed in light brown and black on a specially developed surface which takes a drawing pencil like a good quality drawing paper. Pencil lines of any color may be either washed or erased easily from the chart.

The chart is obtainable at nominal cost, through General Electric air conditioning dealers.

Flow of Fluids in Pipes and Heat Transmission

"Engineering Data on Flow of Fluids in Pipes and Heat Transmission," Technical Paper No. 405, prepared by the product engineering department and published, 1935, by Crane Co., 836 S. Michigan Ave., Chicago, Ill., Planographed, 84 pp. and paper cover, 8½x11 in.

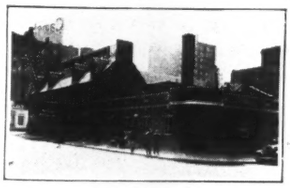
Flow of fluids in piping and heat transmission, two much discussed engineering topics, require experimentation and research to develop consistent methods of calculation. This booklet

The Latest on Air Conditioning

Sixteen Pages on Air Conditioning for theatres, hotels, funeral homes, residences and industrial plants . . . dozens of photographs . . . data on the four kinds of refrigeration applicable. You will want this comprehensive new book . . . ask for your copy today.

The Cluster Theatre in Baltimore, Md., is one of the Dozens of Theatres Air Conditioned with Frick Refrigeration

Air Conditioning with Frick Refrigeration is the answer to your needs for economy with effectiveness. Hundreds of installations (many made long before the term "Air Conditioning" was invented) give Frick the background of experience upon which you can depend. Get full facts and figures now. Branches and Distributors everywhere.



Jack Dempsey's Restaurant, in New York City, is Air Conditioned throughout with Frick Refrigeration

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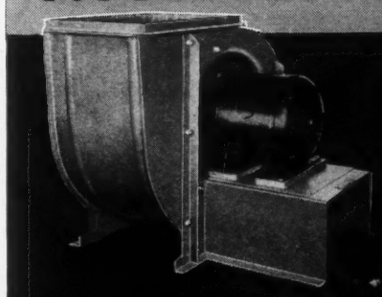

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Where Speed Changes Mean ECONOMICAL OPERATION

Wagner multi-speed motors are especially suitable for air conditioning equipment, refrigeration systems, blowers, fans, conveyors, compressors, or for any machine where it is desirable to operate at more than one constant speed.

No matter what your motor requirement may be, there's a Wagner multi-speed motor designed and built for the job. They are available in 2-speed, 3-speed, 4-speed, constant-torque, constant-horsepower, and variable-torque; horizontal or vertical; 2 or 3 phase; 25 to 60 cycles; ½ to 125 hp.

The insert above illustrates a Wagner 1½ hp., three-speed, constant-torque, type MRP-1 multi-speed motor driving a 3000 c.f.m. exhaust blower. During cold weather one must be careful about operating exhaust fan equipment if the proper amount of heat for comfort is to be retained in a building. Therefore, in cold weather the blower is operated at reduced speeds by turning a switch of the multi-speed motor and adequate ventilation is acquired without dissipation of too great amount of necessary heat.

Ask for a copy of Bulletin 174 which describes Wagner multi-speed motors as well as other types of polyphase motors.

M335-2

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Transformers Motors Fans Brakes

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was prepared with the aim of offering a complete summary of information on these subjects and is based upon results of research carried on by the publisher's engineering personnel or selected from other reliable sources.

Section I on flow of fluids in pipes covers the general considerations involved, flow of high and low pressure air, gas, water, oil, gasoline and steam; determination of pipe sizes; resistance of valves and fittings (abstracted elsewhere in this issue); and presents numerous charts and examples. Section II is concerned with discharge of fluids into atmosphere. Section III, heat transmission, includes information on heat losses from bare pipe in air, insulation, effect of air velocity on heat loss, heating with injected steam, heat transfer through pipes, heating oil and heating water with steam coils, and heat loss from elevated steel tanks.

Section IV, steam, covers steam flash, size of return piping, compares heat transfer with superheated and saturated steam, and presents steam tables. Sections V and VI comprise miscellaneous tables and references.

A large steam flow chart pasted to the back cover is presented and its use described in the first section.

Recent Trade Literature

For your convenience in obtaining copies of bulletins, see coupon on page 107.

No. 700. AIR METERS: Julien P. Friez & Sons, Inc., Baltimore, Md. 2 p. bulletin describing instrument for study and measurement of pressures and vacuums as well as velocities (in fpm) of air in ducts, at grille faces, fans, etc.

No. 701. BOILERS AND RADIATORS: Crane Co.. 836 S. Michigan Ave., Chicago, Ill. 56 p. catalog of tables and technical data, sectional drawings, performance records, etc., for eight different styles of boilers for commercial and residential heating; similar information is given on radiators, and various specialties are described.

No. 702. BOILERS AND STOKERS: National Radiator Corp., Johnstown, Pa. 4 p. folder on Iron Fireman—National stoker—boiler combinations for commercial and industrial heating, briefly describing two series of steel boilers and citing advantages of the combination.

No. 703. BRINE COOLERS: Carbondale Machine Corp., Harrison, N. J. 8 p. bulletin on brine coolers, describing features of design and construction of horizontal, vertical, single pass, and multi-pass types.

No. 704. CHAIN DRIVES: Morse Chain Co., Ithaca, N. Y. Ingenious silent chain drive selector aimed to take the mystery out of silent chain designing; covers a range of ½ to 150 hp. By means of tables and a sliding scale, number of teeth in the sprockets, chain width and pitch, standard center distance, chain length, and sprocket diameters are determined and stock sizes indicated.

No. 705. COMPRESSORS: Worthington Pump and Machinery Corp., Harrison, N. J. 8 p. bulletin describing in detail and giving specifications for single horizontal, single stage steam and motor driven compressors, 11 in. and 13 in. stroke, tapered roller bearings.

No. 706. CONTROLLERS: The Brown Instrument Co., Wayne and Roberts Aves., Philadelphia, Pa.. 24 p. catalog of air operated controllers for temperature, pressure, flow and liquid level illustrating construction and ease of adjustment, "tuning in" the throttling range, automatic reset, and interchangeability of control units.

No. 707. CONVECTORS: National Radiator Corp., Johnstown, Pa. 32 p. catalog of "Aero" cast iron concealed heating units or convectors, describing the line and giving selection and installation data, dimensions, ratings, performance data, notes on special applications, etc.

No. 708. COPPER FITTINGS: American Radiator Co., 40

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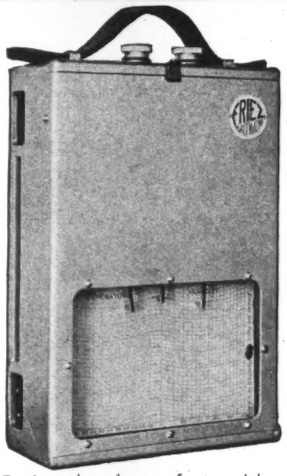

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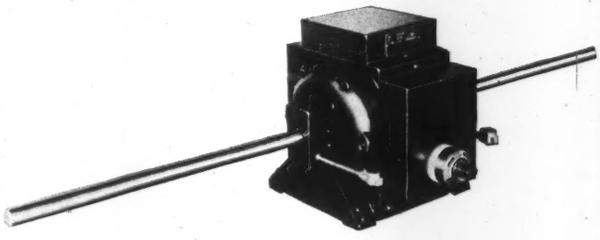

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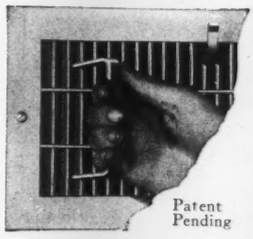

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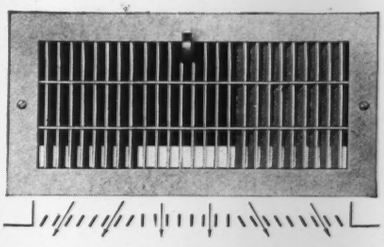

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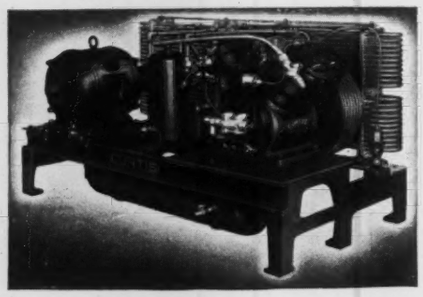

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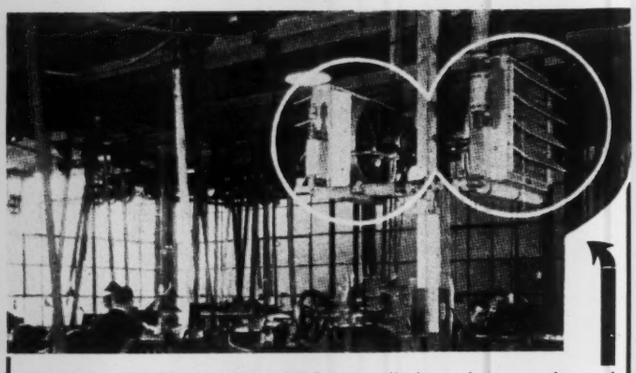

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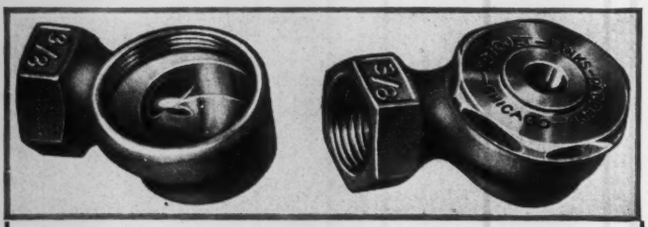

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W. 40th St., New York, N. Y. 6 p. trade net price sheet for "Arco" wrought copper fittings.

No. 709. DRILLS: Rawlplug Co., 98 LaFayette St., New York, N. Y. Booklet on masonry drills with information on proper use.

No. 710. FEEDWATER HEATERS: Worthington Pump and Machinery Corp., Harrison, N. J. 4 p. folder illustrating and briefly describing deaerating feedwater heaters.

No. 711. FUEL OIL HEATERS. Ross Heater & Mfg. Co., 1407-11 West Ave., Buffalo, N. Y. Fuel oil heater and tank suction heater catalog with descriptions, drawings, dimensions, and capacity tables for selection.

No. 712. GASKETS: Goetze Gasket & Packing Co., Inc., New Brunswick, N. J. 64 p. catalog of metallic and semi-metallic gaskets, sheet and stuffing box packings, sealing compounds, gasket cutting tools, valve discs, filter screens, and metal stampings, with diagrams, size and price information. A foreword points out the importance of proper gasket choice.

No. 713. HEATING UNITS: F. C. Williams, Inc., 22805-9 Michigan Ave., Dearborn, Mich., 4 p. folder describing "Airmixt Sally Mander" coke fired portable heating units for plants, snow melting, fog elimination, and general service, with plain or rubber covered wheels. Average capacity, 250,000 Btu per hr, 64,000 cfh fan.

No. 714. METEOROLOGY: Julien P. Friez & Sons, Inc., Baltimore, Md. 16 p. booklet, "Wind News," and supplementary price sheet describing this company's newer wind instruments and illustrating prominent installations.

No. 715. PUMPING UNITS: Lawrence Pump & Engine Co., Lawrence, Mass. 8 p. bulletin describing "Electropump" centrifugal pumping units for small and moderate capacities for circulating hot and cold water and brine, booster service, low pressure boiler feeding, condensate return, air conditioning work, transfer of oil and other liquids, etc. Rating and dimension tables are given.

No. 716. PUMPS: Worthington Pump and Machinery Corp., Harrison, N. J. 4 p. folder stressing reducing water costs with deep well turbine pumps.

Statement of Ownership and Management of "Heating, Piping and Air Conditioning" for October 1, 1935

The following is a statement of ownership, management, etc., as required by the Act of Congress of March 3, 1933, of Heating, Piping and Air Conditioning," published monthly at Chicago, Ill., for October 1, 1935:

State of Illinois, County of Cook, ss: Before me, a Notary Public in and for the State and county aforesaid, personally appeared F. P. Keeney, who, having been duly sworn according to law, deposes and says that he is the business manager of "Heating, Piping and Air Conditioning," and that the following is, to the best of his knowledge and belief, a true statement of the ownership and management of the aforesaid publication, for the date shown in the above caption, required by the Act of August 24, 1912, embodied in Section 411, Postal Laws and Regulations, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business manager are:

Publisher, Keeney Publishing Company, Chicago, Illinois.
Editor, C. E. Price, Chicago, Illinois.
Managing Editor, C. M. Burnam, Jr., Chicago, Illinois.
Business Manager, F. P. Keeney, Chicago, Illinois.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Keeney Publishing Company, 6 North Michigan Avenue, Chicago, Illinois. Stockholders: F. P. Keeney, Chicago; W. J. Osborn, Fairfield, Conn.; R. P. Wettstein, Chicago; C. E. Price, Chicago; R. A. Jack, Cleveland Heights, Ohio.

3. That the known bondholders, mortgagees and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporaton for whom such trustee is acting is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

F. P. Keeney,
Business Manager.

Sworn to and subscribed before me this 1st day of October, 1935.
[My commission expires Feb. 10, 1938.] Grace E. Waymire.
(SEAL.) Notary Public.

No. 717. STOKERS: The Will-Burt Co., Orrville, Ohio. 8 p. bulletin on commercial stokers built in fourteen models, describing in detail their construction and showing various types of buildings in which they are installed.

No. 718. TUBE FABRICATING EQUIPMENT: Parker Appliance Co., Cleveland, Ohio. 24 p. bulletin on tube fabricating equipment, giving complete descriptions, instructions, and price list.

No. 719. UNIT HEATERS: American Blower Corp., 6000 Russell St., Detroit, Mich. 48 p. "Venturafin" unit heater catalog and engineering application guide, with complete information, including general description, capacity tables and detailed instructions on application.

No. 720. UNIT HEATERS: The Fedders Mfg. Co., 57 Tonawanda St., Buffalo, N. Y. Data book on "Series 3" unit heaters in 20 standard models which—with 7 new sizes recently announced—provide capacities up to 1300 E.D.R.

No. 721. UNIT HEATERS: Modine Mfg. Co., Racine, Wis. Catalog of direct suspension type unit heaters, including 4 new ones, with detailed descriptions, information on applications to process as well as heating problems, and instructions for selection.

No. 722. WATER HEATERS: The Patterson-Kelley Co., Inc., East Stroudsburg, Pa. 22 p. catalog of hot water service heaters, including information on water consumption and how to figure amount of steam required to heat water. Detailed descriptions and tables are presented.

No. 723. WATER HEATING EQUIPMENT: Excelso Products Corp., 65 Clyde Ave., Buffalo, N. Y. Catalog of water heating equipment and accessories.

No. 724. WELDING: Harnischfeger Corp., Milwaukee, Wis. 24 p. booklet, "Weld It Well!" covering complete line of "P&H-Hansen" arc welders from 50 to 800 ampere units, giving condensed specifications and performance data and information about fixtures and accessories.

No. 725. WELDING: The Lincoln Electric Co., Cleveland, Ohio. 34 p. booklet of arc welding electrodes and accessories giving complete descriptions, applications and procedures for welding various types of steels, hard facing, etc., and describing and illustrating many accessories for facilitating use of the electric arc.

No. 726. WELDING: The Lincoln Electric Co., Cleveland, Ohio. 40 p. booklet on automatic arc welding by the "electronic tornado," with information on fabrication of large diameter pipe, building large tanks, etc.

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